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THE SIXTY FINEST OBJECTS IN THE SKY.

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The following list has been compiled at the Harvard Astronomical Station in Jamaica, not merely as a summary of the heavens and as a matter of general interest to observers, but also to serve as an aid to those wishing to exhibit particularly beautiful objects to students or visitors. To serve the latter purpose more conveniently a second list is given in which the more northerly of these bodies, with a few southern ones added at the end, are arranged more or less in the order of their right ascension. A third list of attractive objects is given later, all of which have been examined here, but which were not suitable to be entered in either of the previous lists. Since nearly all of those given in the first list are visible from this station, latitude $+18°$, and can thus be compared with one another, it seemed as if such a list could be compiled to better advantage here than at a more northerly observatory. Moreover, one can judge all the objects south of the equator more fairly from here, since they rise to a greater altitude. The two bodies not visible from our latitude were added from memory, as seen with a 13-inch telescope in Arequipa. It may be stated that the list is based not merely on the writer's personal impressions, but also in some degree on the impressions which he has noticed were produced on others to whom the objects have been shown.*

The intrinsic interest of the bodies included has not been considered in compiling the list, as that would differ with the individual, but only their striking character or beauty as seen in the telescope. Since it is obviously impossible to compare the relative beauty of dissimilar objects like a nebula and a double star, the various objects in the heavens have

* Incidentally it may be mentioned that for the casual visitor who merely wishes to see something brilliant and surprising, few objects excite more admiration than a first magnitude star thrown slightly out of focus. The eyepiece should be pushed in rather than pulled out in the case of most telescopes, in order to show the colors to the best advantage.

been divided into nine classes, the more beautiful ones among them selected, and a certain number placed in each class, in the order of their beauty or impressive character. Where the objects were found in nearly opposite regions of the sky, this order was sometimes rather difficult to determine, and intermediate objects were selected to aid in the comparison. In any case it is necessarily more or less a matter of opinion, but it is believed that nearly everyone will agree that the majority of the objects in each class properly belong there. In preparing the lists it may be stated that not only have all the objects included in them been carefully examined by the writer, in some cases many times, but also numerous other bodies taken from various other lists have been compared with these, and the less attractive ones gradually eliminated. The three catalogues on which this list is primarily founded are Bailey's catalogue of Bright Clusters and Nebulæ, H. A. **60** 199, Burnham's General Catalogue of Double Stars, and the Revised Harvard Photometry H. A. **50**. Other catalogues have also been consulted, such as those contained in Webb's Celestial Objects, Upton's Star Atlas, and Chamber's General Astronomy.

The lists were compiled with the aid of a telescope of eleven inches aperture, using powers of 65 and 330. The field of the former is 40′, that of the latter 12′. In general for the nebulae and clusters as large a field as possible should be used, in order to bring out their full beauty. For the stars, with any telescope, a ½-inch eyepiece usually gives the best results. For the objects in the solar system the same power should be employed, if the atmospheric conditions will permit of it, but no matter how excellent the seeing, this power is high enough for the casual visitor or general observer. In the north a 1-inch eyepiece is usually all that the seeing will bear for planetary detail.

The relative attractiveness of the different objects depends somewhat on the size of the instrument. Thus with a 3-inch telescope a large bright cluster like the Pleiades is much more attractive than a fainter smaller object like the double cluster in Perseus, or even than a smaller bright object like *c* Orionis, while with an 11-inch telescope, even with a low power, the Pleiades is inferior to both of them. A similar comparison holds for the great nebula in Andromeda and the Ring nebula in Lyra. In order to decide which objects should be included in the list, each one was described and recorded at the telescope, and the descriptions later compared with one another. Thus in describing a cluster, its diameter was estimated in terms of that of the field. If resolvable, the number of stars it contained was estimated, and their brightness recorded. If not resolvable, as in the case of many of the globular clusters, the outside diameter and the diameter of the brightest region were both estimated, and the cluster was recorded either as

bright, medium, or faint. Sometimes estimates were made on different nights. These were found in general to agree fairly well. In the case of seven of the brighter irregular clusters special studies of them were made, and comparisons between them made the same night at the telescope.

Several of the objects classed here as double stars are in reality triples, or multiples. It is only when there are at least two fainter companions conspicuously near and bright that they have been classed as multiple stars. The distances given are the latest available. Dates and position angles are outside of the scope of this paper, except in the case of multiple stars, when the latter are often necessary for purposes of identification. Visual estimates of brightness are frequently in error by over one magnitude. Photometric measures H. A. **56**, 7, and **64**, 6, are used whenever available, and are given to tenths.

The great majority of the colored doubles are located north of the equator. In the older works on astronomy different brilliant colors are often assigned to these stars. Thus Webb mentions red, green, blue, and purple. With sufficient light all stars are either white or yellow. As we diminish the aperture of the telescope, thus reducing the light, the white stars turn blue and the yellow ones red, while the intermediate ones are colorless or grey. With a moderate aperture the strongly colored doubles may all be described as yellow and blue. The color depends also somewhat on the magnification employed. Yellow stars of the brightness given in this list usually appear more red with a ½-inch eye piece than with either a higher or lower power.

Since the color depends primarily on the type of spectrum, in order to find the so-called red stars we simply select those of type N. There are very few really red stars in the heavens. Those of type M are properly speaking orange colored. In order to bring out the color clearly it is necessary to refocus the telescope accurately on these stars. Stars between the fifth and sixth magnitudes only have been chosen, as being bright enough to be easily found, and to show their color clearly with a moderate aperture. The brightest N star in the heavens is 19 Piscium, magnitude 5.3. Variables have been omitted, although some of them are at times very red; the reason for this being that it was thought necessary that the list should be perfectly reliable, so that the astronomer need not have to explain to his friends, sometimes, that the object on which he had pointed his telescope was really there, although they could not see it.

The majority of the objects included in this list are visible to the naked eye, and can be readily memorized or found by a map,* with-

* Upton's Star Atlas is an excellent one for this purpose.

out recourse to the circles. To assure their identification however, the right ascensions and declinations are also given. For the nebulae and clusters the N. G. C. numbers are inserted, for the multiple and double stars Burnham's Catalogue number, and for the red stars the numbers of the H. R.

TABLE I.

The Solar System.

To the lay mind the most beautiful objects in the heavens are undoubtedly those of the solar system. We shall notice them therefore in the order of what seems to be their general attractiveness, with a few remarks based on our personal experience in exhibiting them through a rather long series of years.

1. The Moon. To most persons this is the most attractive of all celestial objects, especially when seen with not too high a power. Indeed to many persons a view through the finder, showing the whole moon at once, is more beautiful than a view through a larger instrument. To those unfamiliar with a telescope it is well to show both. All phases when not too near the full are of interest, but possibly the most attractive are the two when Theophilus and when the Apennines and Plato are near the terminator. The long shadows crossing the floor of the latter always excite remark when attention is called to them.

2. Saturn. Unique, beautiful, and of interest to the most unintelligent. When seen for the first time, surprise is frequently expressed that it should really resemble the pictures in the text-books. Although showing far less variety than the Moon, it is undoubtedly a more wonderful object. Unless especial attention is called to its various interesting features, such as the shadows on the ball and rings, the belts, the ellipticity, the Cassini division and crepe ring, most of these will pass unnoticed.

3. Jupiter and its satellites. Of more real interest than Saturn, on account of its continually changing cloud belts, and the eclipses, occultations, transits, and shadows of its satellites, but less impressive to the visitor.

4. Venus. Until used to it, the professional astronomer is always surprised at the interest this planet excites, especially when the crescent is narrow. Favorable comment is often expressed on the beautiful colors shown.

5. Mars. Unless the visitor is forwarned, this always proves a most disappointing object. As it usually appears in the Northern States, it has been well described by someone as resembling a ball of butter with a blue fringe round it. It appears best when the Syrtis Major, longitude 280°, is central, especially if near the vernal or autumnal equinox. The equinoxes occur when the heliocentric longitude of the planet is 88° and 268°. At these times one of the polar caps is always conspicuous.

The three remaining planets are of some interest, but are not striking. Even the brightest comets are more pleasing to the visitor when seen through a field glass than through any telescope.

The Nebulæ.

1. The Great Nebula in Orion. 1976, 5^h 30^m, $-5°.4$. Undoubtedly the finest and most detailed of all the nebulae north or south.

2. Greater Magellanic Cloud. Dorado 2070, 5^h 39^m, $-69°.1$. The spira nature of this formation is readily visible to the eye, and like the outer portion of the great nebula in Orion, it is a single, not a double spiral. The central portion is very beautiful.

3. η Carinae 3372, 10^h 41^m, $-59°.2$. Much the largest and brightest of the naked eye nebulæ. For all these objects a very large field is necessary, but the largest field is too small to show this object to advantage. If the nebula were twice as remote it would be much more beautiful than it is. It appears well in a 3-inch glass.

4. Ring Nebula in Lyra. 6720, 18^h 50^m, $+32°.9$. Very small, but does not require a higher power than 70. Its beauty is greatly enhanced by a large field.

5. Great Nebula in Andromeda. 224, 0^h 37^m, $+40°.7$. The largest naked eye nebula visible in the north. Extensive, but shows little detail. The secondary condensation near it is readily visible on shifting the telescope.

6. Ring Nebula in Hydra. 3242, 10^h 20^m, $-18°.1$. Very brilliant, small, and, unlike the other nebulae in this list, requires a high magnification, such as 330. In 1892 the writer observed that it had a bright star in its center. This has now disappeared.

7. The Horseshoe or Omega Nebula in Sagittarius. 6618, 18^h 15^m, $-16°.2$. So named because the faintest visible portion of it is curved.

8. The Dumbbell Nebula in Vulpecula. 6853, 19^h 55^m, $+22°.4$. Obviously a double condensation, but bearing little resemblance to its prototype.

9. The Crab Nebula in Taurus. 1952, 5^h 28^m, $+22°.0$. A somewhat egg-shaped body.

10. Nameless Nebula in Sagittarius. 6523, 17^h 58^m, $-24°.4$. Conspicuous to the naked eye, chiefly on account of the cluster of stars with which it is associated. Some dark lanes within it can be faintly traced similar to those seen in the Trifid. 6514, 17^h 56^m, $-23°.0$, which is near it, and distinctly inferior

11. The Great Spiral nebula in Canes Venatici. 5194, 13^h 26^m, $+47°.7$. This is the finest object of its class, but is always very disappointing to those who have seen only its photograph. This is because it is so faint. Nevertheless the spiral structure can without much difficulty be distinguished in the telescope, and the two condensations are conspicuous.

Globular Clusters.

1. Cluster in Tucana. 104, 0^h 20^m, $-72°.6$. By far the finest of the globular clusters, but very far to the south. Some might indeed rank it as the finest of all sidereal objects.

2. ω Centauri. 5139, 13^h 21^m, $-46°.8$. A somewhat overrated object. Very large, and stars very numerous, but extremely faint. It might rank higher if seen with an aperture of the largest size.

3. Cluster in Hercules. 6205, 16^h 38^m, $+36°.6$, A very fine object.

4. Cluster in Libra. 5904, 15^h 13^m, $+2°.4$ But slightly inferior to that in Hercules.

5. Cluster in Sagittarius. 6656, 18^h 30^m, $-24°.0$. There are no conspicuous globular clusters between 0^h and 12^h north of the equator.

Irregular Clusters.

1. Great Cluster in Carina. 3532, $11^h\ 02^m$, $-58°.1$. The finest irregular cluster in the heavens, and possibly the finest object, outside the solar system. There is no other irregular cluster in the same class with it. It is because it fills the whole field of view in the telescope that its beauty has not hitherto been more generally appreciated.

2. Cluster in Canis Major. 2287, $6^h\ 43^m$, $-20°.6$. Visible to the naked eye.

3. Cluster in Gemini. 2168, $6^h\ 03^m$, $+24°.4$. The stars are arranged in part in curved lines. A naked eye cluster,

4. Double Cluster in Perseus, 869, 884, $2^h\ 12^m$, $2^h\ 15^m$, $+56°.7$, $+56°.6$. The preceding cluster is rather the finer of the two. Conspicuous to the naked eye. These clusters are interesting because so near together, and therefore probably related, but neither taken separately is the equal of N.G.C. 2287, nor 2168.

5. Lesser Cluster in Carina. 3114, $10^h\ 00^m$, $-59°.6$. Perhaps slightly exceeding in splendor the preceding cluster in Perseus. Visible to the naked eye.

6. Cluster in Andromeda. 752, $1^h\ 52^m$, $+37°.2$. Visible to the naked eye.

7. Cluster in Ophiuchus. 6494, $17^h\ 51^m$, $-19°.0$. Comparable to the following cluster in Perseus.

8. Cluster in Scorpius. 6231, $16^h\ 47^m$, $-41°.6$. A small cluster of bright stars.

Coarse Clusters.

1. c Orionis. $5^h\ 30^m$, $-4°.9$. Both c and ι are often neglected on account of the proximity of the Great Nebula.

2. Pleiades. $3^h\ 42^m$, $+23°.8$. Only a portion of this cluster can be seen at one time in the telescope.

3. Cluster in Scorpius. 6475, $17^h\ 47^m$, $-34°.8$. Many of the stars are arranged in lines approximately at right angles.

4. Cluster in Carina near False Cross. 2516, $7^h\ 57^m$, $-60°.6$. Resembles Praesepe.

5. Praesepe in Cancer. 2632, $8^h\ 34^m$, $+20°.3$. A well known naked eye cluster.

Multiple Stars.

1. 11 Monocerotis. 3402, $6^h\ 24^m$, $-7°.0$. 132°.106°, 7″, 3″, 4.7, 5.2, 5.6. A very fine object. There is a remote faint companion 55°, 26″,12.

2. θ^1 Orionis. 2837, $5^h\ 30^m$, $-5°.4$. A sextuple star in the heart of the Great Nebula. Struve's letters of designation are now in general use, the four principal stars being lettered in the order of their right ascension; E lies near A, and F near C. Taking the stars in the order, A, B, C, D, E, and F, their magnitudes are 6.8, 7.9, 5.4, 6.8, 10, and 11. Their position angles and distances are AB 32°, 8″.7, AC 131°, 13″.0, AD 95°, 21″.6, AE 352°, 4″.3, CF 121°, 4″.0. Very faint stars in the vicinity were discovered by Clark and Barnard, visible only with the largest telescopes.

3. ϵ Lyrae. 8782, $18^h\ 41^m$, $+39°.5$. Two bright doubles and two faint stars between them. ϵ^1 26°, 3″.0, 5.1 and 6.0. ϵ^2 155°, 2″.6 5.1 and 5.4. The distance between the principal components is 207″.1.

4. 12 Lyncis. 3559, $6^h\ 37^m$, $+59°.5$. 118°, 307°, 2″, 8″, 5.3, 6.2, 7.4.

5. σ Orionis. 2883, $5^h\ 34^m$, $-2°.6$. A sextuple star which appears as a double triple. 329°, 237°, 83°, 61°, 231°, 0″.2, 11″, 13″, 41″, 30″, 4.1, 6.1, 10.8, 6.5, 6.7.

6. ν Scorpii. 7533, $16^h\ 06^m$, $-19°.2$. A double double. AB 0°, 0″.7, 4.3, 6.8, CD 39°, 1″.1, 4.3, 6.5. The distance between the principal components is 41″.

7. ζ Cancri. 4477, $8^h\ 06^m$, $+18°.0$. —°, 110°, 1″, 5″, 5.6, 6.3, 6.0. Binary 60 years.

8. ξ Scorpii. 7487, $15^h\ 59^m$, $-11°.1$, —°, 63°, 1″, 7″, 4.8, 5.1, 7.2. Binary 44 years.

The position angles of the closer components of these last two stars cannot be given since they are rapidly changing.

White Double Stars.

1. α Centauri. $14^h\ 33^m$, $-60°.4$, 18″.6, 0.3, 1.7. By far the finest double in the sky. Period 81 years.

2. α Crucis. $12^h\ 21^m$, $-62°.5$, 4″.7, 1.6, 2.1. A sixth magnitude companion, distance 90″.

3. α Geminorum. 4122, $7^h\ 28^m$, $+32°.1$, 5″.7, 2.0, 2.8. A ninth magnitude star 73″ distant.

4. γ Virginis. 6243, $12^h\ 37^m$, $-0°.9$, 6″.2, 3.6, 3.7. Binary. Period 190 years.

5. γ Leonis. 5388, $10^h\ 14^m$, $+20°.4$, 3″.7, 2.6, 3.8. Both components yellow rather than white.

6. ζ Orionis. 2902, $5^h\ 36^m$, $-2°.0$, 2″.4, 2.0, 4.2.

7. ζ Ursae Majoris. 6482, $13^h\ 20^m$, $+55°.4$, 14″.5, 2.4, 4.0.

Colored Double Stars.

1. α Andromedae. 1070, $1^h\ 58^m$, $+41°.8$, 10″.7, 2.3, 5.1. Clearly the finest colored double in the sky. The colors are marked and the components bright, and closer than in many cases. The companion is a close double, making the star a triple.

2. α Herculis, 7914, $17^h\ 10^m$, $+14°.5$, 4″.6, 3.5, 5.4. Bright and close.

3. ϵ Bootis. 6993, $14^h\ 41^m$, $+27°.5$, 2″.8, 2.7, 5.1. A fine close pair.

4. β Cygni. 9374, $19^h\ 27^m$, $+27°.8$, 34″.7, 3.2, 5.4. If the components were closer it would rank higher, since the colors are very marked.

5. 32 Eridani. 1939, $3^h\ 49^m$, $-3°.2$, 6″.9, 5.0, 6.3.

6. δ Cephei. 11772, $22^h\ 25^m$, $+57°.9$, 19″.8, 3, 5. The brighter component is variable through a small range. Wide doubles that are variable are unusual.

Red Stars.

1. 19 Piscium. 9004, $23^h\ 41^m$, $+2°.9$, 5.3.
2. — Canum Venaticorum. 4846, $12^h\ 40^m$, $+46°.0$, 5.5.
3. — Horologii. 977, $3^h\ 10^m$, $-57°.7$, 5.7.
4. U Antliae. 4153, $10^h\ 31^m$, $-39°.0$, 5.8.
5. — Aurigae. 2405, $6^h\ 30^m$, $+38°.5$, 5.9.

Dividing that portion of the heavens north of $\delta\ -30°$ into eight sections of 3^h each, the following table is arranged to show what may

be considered as the finest object of each class in each section. Since this list is forced to cover each of the eight sections, some of the objects mentioned in it are not as striking as those in its predecessor. They have accordingly been divided into three grades, the finest objects being indicated by a 1 following the position. The word "none" indicates that there was no object sufficiently fine to be entered in that class. It does not necessarily mean that there was no object at all. This list is suggested for the use of teachers and others, but should obviously be subject to modifications dependent on the latitude of the observer and the aperture of his telescope.

TABLE II.

Class	Object	No.	α	δ	Grade
		0^h to 3^h			
			h m	°	
Nebula	— Andromedae	224	0 37	+40.7	1
Globular cluster	None	—	—	—	—
Irregular "	— Persei	869,884	2 15	+56.7	1
Multiple star	ι Cassiopeiae *	1262	2 21	+67.0	2
White double	γ Arietis	993	1 48	+18.8	2
Colored "	γ Andromedae	1070	1 58	+41.8	1
Red star	χ Pegasi (Ma)	45	0 09	+19.6	3
		3^h to 6^h			
			h m	°	
Nebula	θ Orionis	1976	5 30	− 5.4	1
Globular Cluster	— Aurigae †	2099	5 46	+32.5	2
Irregular "	— Aurigae	1912	5 22	+35.8	2
Coarse "	c Orionis	1977	5 30	− 4.9	1
Multiple star	θ Orionis	2837	5 30	− 5.4	1
White double	ζ Orionis	2902	5 36	− 2.0	2
Colored "	32 Eridani	1939	3 49	− 3.2	2
Red star	119 Tauri (Ma)	1845	5 26	+18.5	3
		6^h to 9^h			
			h m	°	
Nebula	—Camelopardalis	2403	7 27	+65.8	3
Globular cluster	None	—	—	—	—
Irregular "	— Canis Majoris	2287	6 43	−20.6	1
Coarse "	Praesepe in Cancer	2632	8 34	+20.3	1
Multiple star	11 Monocerotis	3402	6 24	− 7.0	1
White double	α Geminorum	4122	7 28	+32.1	1
Colored "	ι Cancri	4763	8 41	+29.1	2
Red star	— Aurigae (N)	2405	6 30	+38.5	1

* The close pair are very unequal and not well adapted to small telescopes.

† Resolvable. Intermediate between the globular and irregular clusters. Slightly larger than ω Centauri but with brighter and far fewer stars. A red star in the center. It may be a comparatively near small globular cluster.

Class	Object	No.	α	δ	Grade
		9^h to 12^h			
Nebula	Ring in Hydra	3242	10 20	−18.1	1
Globular cluster	None	—	—	—	—
Irregular "	None	—	—	—	—
Multiple star	90 Leonis	5833	11 28	+28.3	3
White double*	γ Leonis	5388	10 14	+20.4	2
Colored "	None	—	—	—	—
Red star	— Urs. Majoris (N)	4195	10 38	+67.9	1
		12^h to 15^h			
Nebula	Spiral in Can. Ven.	5194	13 26	+47.7	1
Globular cluster	Can. Venaticorum	5272	13 38	+28.9	2
Irregular "	None	—	—	—	—
Multiple star	None	—	—	—	—
White double	γ Virginis	6243	12 37	− 0.9	2
Colored "	ε Bootis	6993	14 41	+27.5	1
Red star	— Can. Venat. (N)	4846	12 40	+46.0	1
		15^h to 18^h			
Nebula	M8 Sagittarii	6523	17 58	−24.4	2
Globular cluster	— Herculis	6205	16 38	+36.6	1
Irregular "	— Ophiuchi	6494	17 51	−19.0	1
Coarse "	— Oph. B.A.C. 6012	—	17 41	+ 5.8	2
Multiple star	ν Scorpii	7533	16 06	−19.2	1
White double	δ Serpentis	7318	15 30	+10.9	2
Colored "	α Herculis	7914	17 10	+14.5	3
Red star	κ Cor. Bor. (Mb)	5901	15 48	+36.0	1
		18^h to 21^h			
Nebula	Ring in Lyra	6720	18 50	+32.9	1
Globular cluster	— Sagittarii	6656	18 30	−24.0	1
Irregular "	— Ophiuchi	6633	18 23	+ 6.5	2
Multiple star	ε Lyrae	8783,5	18 41	+39.6	1
White double	θ Serpentis	8914	18 51	+ 4,1	3
Colored "	β Cygni	9374	19 27	+27.8	1
Red star	104 Herculis (Ma)	6815	18 08	+31.4	3
		21^h to 0^h			
Nebula	None	—	—	—	—
Globular cluster	— Pegasi	7078	21 25	+11.7	3
Irregular "	— Cygni	7092	21 29	+48.0	3
Multiple star	μ Cygni	11214	21 39	+28.2	3
White double	ζ Aquarii	11743	22 24	− 0.5	2
Colored "	δ Cephei	11772	22 24	+57.8	2
Red star	19 Piscium (N)	9004	23 41	+ 2.9	1

* Really yellow

The following Supplementary List contains certain objects south of −30°, which are finer than those given above, and may be substituted for them by southern observers. The last object mentioned is visible at most northern observatories.

	Character	Name	No.	α	δ	Grade
				h m	°	
0h to 3h	Globular cluster	47 Tucanae	104	0 20	−72.6	1
3h to 6h	Red star	— Horologii (N)	977	3 10	−57.7	1
9h to 12h	Nebula	η Carinae	3372	10 41	−59.2	1
"	Irregular cluster	—Carinae	3532	11 02	−58.1	1
"	Red star	U Antliae (N)	4153	10 31	−39.0	1
12h to 15h	Globular cluster	ω Centauri	5139	13 21	−46.8	1
"	Irregular cluster	κ Crucis*	4755	12 48	−59.8	2
"	White double	α Centauri	—	14 33	−60.4	1
15h to 18h	Coarse cluster	2 Scorpius	6475	17 47	−34.8	1

Table III gives a list of all the objects contained in Table II that are not given in Table I. Table IV gives a third list. These objects are inferior to those given in Table I, but are finer than those marked 3 in Table III. As far as the writer is aware they complete the list of really fine celestial objects, but he would be glad to receive suggestions of other objects which it is thought might properly be included in these lists.

TABLE III.

OBJECTS IN TABLE II NOT CONTAINED IN TABLE I.

Character	Name	N. G. C.	β	HR	α	δ	Grade
					h m	°	
Red star	χ Pegasi			45	0 09	+19.6	3
White doub.	γ Arietis		993		1 48	+18.8	2
Multiple	ι Cassiopeiae		1262		2 21	+67.0	2
Irreg. clus.	— Aurigae	1912			5 22	+35.8	2
Red star	119 Tauri			1845	" 26	+18.5	3
Glob. clus.	— Aurigae	2099			" 46	+32.5	2
Nebula	— Camelopard.	2403			7 27	+65.8	3
Colored doub.	ι Cancri		4763		8 41	+29.1	2
Multiple	90 Leonis		5833		11 28	+28.3	3
Irreg. clus.	κ Crucis	4755			12 48	−59.8	2
Glob. clus.	— Can. Venat.	5272			13 38	+28.9	2
White doub.	δ Serpentis		7318		15 30	+10.9	2
Red star	κ Coronae Bor.			5901	" 48	+36.0	3
Coarse clus.	— Ophiuchi	(B.A.C.)6012			17 41	+ 5.8	2
Red star	104 Herculis			6815	18 08	+31.4	3
Irreg. clus.	— Ophiuchi	6633			" 23	+ 6.5	2
White doub.	θ Serpentis		8914		" 51	+ 4.1	3
Glob. clus.	— Pegasi	7078			21 25	+11.7	3
Irreg. clus.	— Cygni	7092			" 29	+48.0	3
Multiple	μ Cygni		11214		" 39	+28.2	3
White doub.	ζ Aquarii		11743		22 24	− 0.5	2

* A small and somewhat over-rated object. It contains one red and three yellow stars, also about a dozen others brighter than the twelfth magnitude.

TABLE IV.

Additional Objects of Grade 2.

N.G.C.	Constellation	α	δ
Nebulae			
		h m	°
253	Ceti	0 43	−25.8
3031	Ursae Maj.	9 47	+69.5
3034	Ursae Maj.	9 48	+70.2
4594*	Virginis	12 35	−11.1
6514†	Sagittarii	17 56	−23.0
6543‡	Draconis	17 58	+66.6
Globular clusters			
1851	Caeli	5 11	−40.2
3201	Velorum	10 14	−45.9
4590	Hydrae	12 34	−26.2
6121	Scorpii	16 18	−26.3
6218	Ophiuchi	16 42	− 1.8
6254	Ophiuchi	16 52	− 4.0
6705	Scuti	18 46	− 6.4
6752	Pavonis	19 02	−60.1
6809	Sagittarii	19 34	−31.2
Irregular clusters			
1960	Aurigae	5 30	+34.1
2099	Aurigae	5 46	+32.5
2323	Monocerotis	6 58	− 8.2
2422	Puppis	7 32	−14.3
2482	Puppis	7 51	−24.0
2548	Monocerotis	8 09	− 5.5
3293	Carinae	10 32	−57.7
6405	Scorpii	17 34	−32.2

N.G.C.	Constellation	α	δ
Coarse clusters			
		h m	°
2451	Puppis	7 42	−37.7
6227	Scorpii	16 45	−41.0
β White doubles			
1061	α Piscium	1 57	+ 2.3
—	θ Eridani	2 54	−40.7
4197	*k* Puppis	7 35	−26.6
5734	ξ Urs. Maj.	11 13	+32.1
—	π Lupi	14 58	−46.7
7493	β Scorpii	16 00	−19.5
7905	A Ophiuchi	17 09	−26.4
—	γ Cor. Austr.	19 00	−37.2
Colored double			
6212	24 Com. Ber.	12 30	+18.9

* Saturn nebula.
† Trifid nebula.
‡ Bright planetary nebula.

The following objects were selected in the main from lists purporting to contain especially fine objects, published by various authorities. They have all been examined here, but have been rejected for the purposes of this paper. While some of them were found to be fairly satisfactory, many were clearly hopelessly inferior, and could never have been examined by those who compiled the lists. None are superior to the third grade. The markedly inferior ones are printed in italics.

Nebulae: N. G. C. 55, 598, *613*, 2683, 2903, 3115, 3132, 3379, 3587 (Owl), 3623, *4254*, *4258*, *4374*, *4382*, *4472*, *4501*, 4736, *4826*, *5055*, *5236*, *5367*, 7009, 7331, 7662.

Globular clusters: N.G.C. 288, 1291, 1387, 1399, 1436, *1792*, 1904, 5024, 5286, 5986, 6171, *6229*, 6266, 6273, 6397, 6402, 6541, *6603*, 6626, *6732*, 6779, 7089, 7099.

Irregular clusters: N.G.C. *225*, *581*, *654*, *663*, *1039*, *1512*, 2360, 2437, 2447, *2477*, 2547, 2682, *2818*, *2932*, *3766*, 6067, 6087, *6259*, 6531, 6611, 6645, 6694, 6811 6866, *6885*, *6940*, *7243*, 7654, 7789.

Multiple stars: β 732, 6296, 7258, 10643.

White double stars: β 6313.

Colored double stars: β 426, 1440 3692, 4771, *5111*, *5765*, 6102, 6296, 6313 7034, *7352*, ϵ Normae, 7631, 7928, *8302*, *8788*, *10036*, *10401*, *10509*, 10932, 11205, *11576*, 12196, *12292*, 12304, 12666.

Omitting the five bodies of the solar system, there are 55 objects in Table I, 21 in Table III, and 34 in Table IV, 110 in all. Of these, 55 are of grade 1, 45 of grade 2, and 10 of grade 3. Dividing the heavens into four equal zones from $\delta + 90°$ to $+30°$, $+30°$ to $0°$, $0°$ to $-30°$, and $-30°$ to $-90°$, we find that the distribution between them of grades 1 and 2 is as follows:—22 per cent in the first, 21 in the second, 32 in the third, and 25 in the last. We find a slight preponderance in the third zone, but if we consider only the very finest objects, the preponderance in the fourth becomes very marked. The seven finest objects south of $-45°$, the nebulae in Dorado and Carina, the globular clusters in Tucana and the Centaur, the irregular cluster in Carina, and the white doubles in the Centaur and Cross are but poorly balanced by the nine finest objects in all the rest of the sky. These nine may be given as the nebulae in Orion and Lyra, the globular cluster in Hercules, the irregular and coarse clusters in Canis Major, Perseus, and the Pleiades, the triple star in Monoceros, and the doubles in Gemini and Andromeda. Of these the nebula in Orion and the doubles in Gemini and Andromeda are the only bodies that may be said to be in the same class with the seven great southern objects, and even the Orion nebula itself is distinctly inferior in impressiveness to the clusters in Carina and Tucana. It is rather singular that five out of the seven southern objects should lie within an area measuring but 30° by 20°, or rather less than three times the size of the great square of Pegasus.

If we arrange the 100 objects of the first and second grade according to their distribution with regard to the galactic equator, we find that they may be divided into five groups, consisting of (*a*) nebulae, (*b*) globular clusters, (*c*) irregular and coarse clusters, (*d*) multiple stars, and (*e*) double and red stars. Of the nebulae seven are found to the north and ten to the south of this equator, in all the other groups the preponderance is to the north, amounting in all to 49 to the north and 34 to the south. In the first column of Table V these groups are arranged in the order of their general concentration about the equator. The second column shows the number lying within 5° of this circle, the third column those lying within 30° of it, the fourth those lying at a greater distance, and the last the totals in each group.

TABLE V.

DISTRIBUTION WITH REGARD TO THE GALACTIC EQUATOR.

Groups	0°—5°	0°—30°	30°—90°	Totals
Irreg. and coarse clusters	15	27	0	27
Multiple stars	0	9	0	9
Nebulae	6	11	6	17
Globular clusters	2	10	6	16
Double and Red stars	5	15	16	31
Totals	28	72	28	100

The distribution of the irregular and coarse clusters is the most dependent on the equator, more than half lying within 5° of it, and none lying at a greater distance than 30°. Oddly enough the multiple stars seem to show the same influence, although we should not otherwise have thought of associating them with the clusters. Although they number only nine, yet the chance that the distribution shown is due merely to accident is but one in 512. One-third of the nebulae lie within 5° and two-thirds within 30° of the equator. In the case of the globular clusters the effect is less marked, and more examples would be necessary to verify it, were not such a relation already known. Its existence seems adverse to the theory that these clusters are objects lying far beyond the galaxy, although such may nevertheless be the case. The double and red stars show no appreciable condensation about the equator.

Mandeville, Jamaica, B. W. I.
October 7, 1916.

THE MORNING STAR

Star in the east when wakes the Sun's faint glow,
Shining so bright on fell and field below,
On field and fell where sleeps chill winter's snow
While restless March winds wander to and fro;
O'er yonder knoll which rises dark and low
Star in the east when wakes the Sun's first glow!

CHARLES NEVERS HOLMES.

41 Arlington St.
Newton, Mass.

A FEW PRE-COPERNICAN ASTRONOMERS.

EDITH R. WILSON.

"The lamp burns low and through the casement bars
Grey morning glimmers feebly." *Paracelsus*: R. BROWNING.

As Astronomy is one of the oldest of sciences, so it is one of those whose progress has been perhaps most gradual. It is hard for us in the noon tide splendor of twentieth century accomplishment, with its fairly dazzling array of recent astronomic achievements, to recall the steps by which the pioneers of European Astronomy made slow and painful advance through the darkness which, on the dissolution of the Roman Empire, threatened to extinquish the light of science. Yet it may be well for us, at times, to pause, so to do, lest in despising the "day of small things," we be found guilty of ingratitude from underrating our debt to the men whose toilsome and comparatively insignificant labors yet made possible the brilliant successes of today; the men who dug the foundations of that immense structure of mathematical and astrophysical research which twentieth century science is uprearing ever higher. Without such retrospect too, we may lose even the very remembrance and cognizance of those lesser lights whose accumulated glow gradually dispelled the mists of ignorance and ushered in the dawning of a brighter day. For dark as was the period immediately succeeding the Fall of Rome, its darkness was yet the grey pallor heralding the silver footed dawn, rather than that dull crimson which reddens only to fade into utter gloom. By the fifth century, the Roman legions had been withdrawn from east and west and the Imperial City lay crumbling to its fall, trembling before the inroads of devasting hordes. Corrupt and effete, Roman civilization had lost the vigor which had once made its armies invincible and was falling to decay quite as much through its own internal weakness as through outward pressure. Such as it had become, however, it continued to maintain itself at Byzantium for a full millenium, in semi-orientalized decadence, until in 1453, that city fell before the sword of the victorious Turk, as, a millenium before, ancient Rome had fallen before the inroads of Goth and Hun.

But during these centuries, Western Rome had conquered her conquerors. The barbarians of the north had been won to Christianity, while the forces of Islam, pressing in impetuous torrent on south and west, had been met and parried, the Battle of Tours, in 750 A. D.

definitely deciding that Europe should be Western, not Oriental in its civilization. It was a strenuous period of rudimental strife, hardly favorable to the cultivation of science, or framed for the calm delights of studious research. But yet the night was not starless, and even at the darkest hour, the lamp of knowledge was never wholly extinguished, as historic record is more and more fully showing us.

Very early the attention of the church, upon whom the task of education now largely devolved, was called to the study of Astronomy by the imperative need of adjusting her Easter Kalendar. As early as 208 A. D. the Bishop of Alexandria, then the home of Astronomy, appointed a committee of scholars to calculate a cycle for determining the proper date of the Pascal full moon, in order that the Easter Observance might be correctly celebrated, while, at about the same time, Hippolytus, Bishop of Porto, an Alexandrian by birth, and generally accredited as the author of the "Philosophumena," either introduced, or obtained distinction through his proficiency in teaching, the "Computum." This distinctly Christian science was, as Durandus tells us [Rational, lib. 8, c. 1], simply a method for calculating Easter, introducing as much Astronomy and Arithmetic as was necessary for the purpose. Hippolytus also composed two cycles, determining the date of Easter for 112 years, a feat which won for his memory the erection of a statue which represents him as seated with the cycles engraved on his episcopal chair: a memento preserved to this day in the "Christian Museum" of the Lateran.

In A. D. 325, the Council of Nice laid down exact and stringent rules for determining the date of Easter, the calculations for which were to be made at Alexandria and communicated by the Bishop of that city to the See of Rome. From this time on, until the promulgation of the Gregorian Kalendar by Gregory XIII, in 1582, it naturally became the constant endeavor of the authorities at Rome, by encouragement and patronage, to draw to that centre the highest astronomic talent of the times. Thus Theophilus of Alexandria, who presided over that See from 385 to 412 A. D., himself constructed an elaborate Easter Cycle, while in 457, Pope Hilary appointed Victor of Aquitaine to revise the Kalendar, and a little later, Dionysius Exiguus, or Dionysius the Little, a Scythian monk, took the same matter in hand, at Rome, where he was then residing as Abbot of a convent. The period known from his name as the great Paschal, or Dionysian Period, (although first suggested by Victor), remained in use until the Gregorian Reformation. It consisted of a solar-lunar cycle of 28×19, or 532 years, including all variations of the new moon in respect to the day of the week and of the month, so that, at its expiration, the new moons, it was supposed, would recur in the same order. Owing to the errors both of the Julian year and of the Metonic Period, it was of course inaccurate; the perfect adjustment

of the solar-lunar kalendar, with the exact determination of the tropical year, requiring a refinement of calculation quite beyond the astronomic attainment of that day.

Meanwhile the classic authorities on Astronomy were studied, as far as circumstances permitted, though chiefly through the medium of later Roman and Alexandrine commentators. Among these were the two Theons, of Smyrna, and Alexandria, Macrobius Simplicius, and Martianus Capella. To the first author, writing in the second century after Christ, we are indebted, as Dreyer tells us in his "Planetary Systems", for "most valuable sources of information about Greek Cosmology and Astronomy", while of his Alexandrine namesake (365 A. D.), Weidler adds, that his commentaries on Aratus and Ptolemy are "extremely interesting and instructive, although neither has been translated." Indeed, Theon ranked as an astronomer of no mean repute in his day, although, in popular fame, he has been somewhat overshadowed by his more celebrated daughter, the beautiful and unfortunate Hypatia, whose terrible fate has been so often told. Leaders of a reactionary party, whose aim was to reëstablish the worship of the ancient gods of Greece and Rome, they had excited the fears of the populace, who, maddened, finally, by the influence of the gifted Hypatia over the Prefect Orestes, brutally attacked her in the streets and foully put her to death. That pagan persecution was still a recent and very real thing in their minds, and that some of those who so horribly mutilated her may have seen their own mothers or sisters exposed in the arena to infamy, or the tooth of wild beasts, may go far to explain, though in no wise to justify, their ferocity. That their wrath was not directed exclusively against astronomers, or even pagans, is clearly shown by the fact that, just 52 years later, one of their own bishops was the victim of a very similar assault, his mutilated body being dragged through the streets and finally committed to the flames in a factional strife.*

But to return to our theme; of the remaining commentators noted, Macrobius gives us a little insight into the astronomical system of "the Egyptians," in the meagre way at least, in which some details of their theory were handed down by the Greeks, and is the author of a singular and arbitrary attempt to determine the size of the sun: while the Carthaginian, Martianus Capella, who also wrote early in the fifth century, in the eighth book of his "Satyricon," supplied the middle ages with a popular textbook on Astronomy, which was long used, and is still noteworthy as containing, beside the statement of the old Egyptian belief as to the revolution of Venus and Mercury around

* Cambridge Mediaeval History, Vol. I, p. 513.

the sun, quite clear references to the heliocentric system in regard to the earth, derived perhaps from Hicetas of Syracuse, 344 B.C. Capella was one of the writers quoted long afterwards by Copernicus. The name of Simplicius has been immortalized by Galileo's use of it in his "Dialogo" as the exponent of Aristotle's views. His Commentary on Aristotle's "De Coelo" being that most widely known in the Middle Ages. All these works, however, show us rather what of classic culture still lingered in the fallen Roman Empire, than point us to any fresh stirrings of intellectual life among their rude conquerors. They supplied simply the *material* from which the latter were to glean all that could be learned of the science of Astronomy until the translation of Ptolemy's Almagest through Arabic media. Among the first to profit by Arab learning, as established in Spain, was St. Isidore, Bishop of Seville (570-636 A.D.). His book, "Of the Origins", together with a smaller treatise, "De Rerum Natura", were drawn up for the use of his Cathedral School; the second Council of Toledo, in 531, having passed several canons bearing on the establishment of such schools in connection with each Cathedral*. In these two writings, St. Isidore expresses himself "very sensibly", as Dreyer tells us, "on the constitution of the world" recognizing the spherical form of the earth, the antipodes etc., and touching on the size and distance of the planets as then held in the geocentric system.

Turning our eyes now to the distant north, we find the English monk, Bede, the most eminent writer of his day, in his quiet retreat at Yarrow, also devoting a portion of his time to astronomy. In his "Treatise on the Kalendar", he shows that he realizes the need of reform, and dwells on the fact that at his time (673-735 A.D.), the equinoxes fell three days earlier than at the era of the Council of Nice. But though invited to Rome by Pope Sergius, Bede could not be persuaded to leave his beloved Yarrow, where he continued to write his "Natura Rerum" and "De Temporum Ratione", in which he dwells on the spherical form of the Earth, explains the ebb and flow of the tides by the attractive power of the moon, shows that the sun is eclipsed by the intervention of the moon, the moon by the intervention of the earth. That he was familiar with Greek is plainly shown by his frequent quotations from Greek authors, especially from Homer, who had not then been translated. But such familiarity is easily explained by his friendship with Theodore of Canterbury, himself a Greek, being a native of St. Paul's city of Taurus, who had been recently appointed Primate of England. Since Bede has been cited as one of those who ridiculed the doctrine of the *antipodes*, it may be well to quote his exact words regarding the

* Drane. Christian Schools and Scholars, p. 13.

shape of the earth. "We call the Earth a globe", he writes, "not that it is absolutely the perfect form of a globe, by reason of the unevenness of hills and plains, but because its whole compass, if comprehended within the circumference of lines, would make the figure of a globe*. When then in "De Temporum Ratione", where, as Dreyer tells us, he shows a fair notion of the principal celestial phenomena, he adds, that we cannot accept narrations about the antipodes, since we know of no one "who has crossed the torrid zone, and found human beings beyond it," it is plain Bede used the word antipodes to denote dwellers in antipodal regions, and not to deny the existence of opposite poles. Bede plainly says indeed that he believes only two zones to be habitable.

This matter of the antipodes is one wherein mediaeval scholars have been most largely charged with ignorance and prejudice. No doubt such existed, yet it is evident too, that the true doctrine was taught. Clemens Romanus† in his epistle to the Corinthians, as early as 96 A. D. alludes to the antipodes and seems to find no difficulty in accepting the belief, either as to place or inhabitants. The oft told tale of St. Fergil and the antipodes is certainly inconclusive. Fergil, or Virgil, was an Irish monk of the eighth century, presiding originally as Abbot of Aghaboe in the present county of Queen's. He left his monastery in 745 to undertake a pilgrimage to the Holy Land, but was apparently directed to proceed no farther than Salzburg, Germany, where he was made Abbot of St. Peter's. Here occurred his discussion with St. Boniface on a purely religious matter. In writing for decision to Pope Tachary, St. Boniface, however, took occasion to complain of Virgil for teaching in his lectures, that there was another world and other people under the earth, another sun and another moon." Poor Virgil was summoned to Rome to account for his errors, but his explanation of his own teaching appears to have been satisfactory, as he was shortly after made Bishop of Salzburg, and in 1223 solemnly canonized by Gregory XIII.

The authority of greatest weight against the belief in the antipodes, i. e., *men* living at the opposite pole of the earth, is St. Augustine, and he limits himself to saying:‡ "There is no reason for believing it, since, those who affirm it do not claim to possess any actual information but merely conjecture" etc. The difficulty for all these writers was evidently a religious, not an astronomical one.

The year 781 brings us to the Court of Charlemagne, to find Alcuin, the pupil of Bede, installed as head of the famous Palatine, or

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* Bede; De Natura Rerum: C. XVI. 118.

† Clemens Romanus; Lightfoot Ed. I. p. 282.

‡ St. Augustine; De Civitate Dei: XVI, 9.

Royal School, which that monarch had established. Astronomy was one of the subjects under his charge and a letter is still preserved, written by him to his royal patron, to explain the erratic movements of the planet Mars, which had perplexed the Court by remaining invisible the whole of that year, 798. Alcuin's reply shows that he tested authority by observation, for he says, "What has now happened to Mars, is frequently observed of all the other planets, namely that they remain longer under the horizon than is stated in the books of the ancients. The rising and setting of the stars vary from the observations of those who live in the southern and eastern parts of the world, where the masters chiefly flourished who have set forth the laws of the universe."

The reign of Charlemagne was also noteworthy for an observation which would have been most valuable had its observer understood its import. On the 17th of March 807, the Benedictine monk, Adelmus, saw a large spot on the surface of the sun, which remained visible for eight days. He records that it was on the upper part of the sun's disk and that clouds prevented his noting its ingress and egress, from which it would appear to have visibly moved. Having never heard of a spot on the sun, however, nor venturing to suggest such a thing, the perplexed astronomer could only propose a transit of Mercury! The same year witnessed an occultation of Jupiter by the moon, recorded as evidence of the superior distance of the planet. But such phenomena had been long before noted.

Travel and exploration about this time were producing clearer ideas as to geography, which in turn, reacted on astronomy. Irish missionaries had visited Iceland and the Orkneys, and Dicuil, in his book on the "Measurement of the Earth", shows that he clearly understood the phenomena of the "oblique sphere". Maps, too, were improving. Dreyer mentions several made after the design of Beatus, a Spanish priest of the eighth century, who seems to have kept in touch with early navigators.

But alas, the century which had opened so auspiciously for learning under the strong hand and enlightened policy of Charlemagne was destined to close in fire and blood! The dismemberment of his empire, the incursions of Danes and Northmen on the one side, with fresh inroads of the Saracens on the other, were factors in the general desolation which succeeded his death and gave to the tenth century the title of the "Iron Age." Everywhere, blackened villages and ruined monasteries, fair fields laid desolate, famine and pestilence stalking, like gaunt spectres, on the heels of war. The Cathedral schools were abandoned. Naturally, astronomy suffered. Hear Ingulphus lament the loss of the armillary sphere, which had formed the astronomical

treasure of the Abbey of Croyland, then recently destroyed by the Danes. "We then lost a most beautiful and precious table, fabricated of different kinds of metal according to the variety of the stars and heavenly signs. Saturn was of copper, Jupiter of gold, the sun of latten, Mercury of Amber, Venus of tin, the moon of silver. The eyes were charmed as well as the mind instructed by beholding the colure circles, with the zodiac and all its signs, formed with wonderful art of metals and precious stones according to their several natures, forms, figures, and colors. It was the most renowned nadir of all England*."

This adornment of the celestial globes points to a certain popular interest and regard for astronomy throughout the Middle Ages, however at fault as to its theory. An anecdote, related of the Emperor, Frederic II, by Weidler, attests the same. Wishing to show the abbot of St. Gall what he considered his greatest treasures he placed before him his little son, Konrad, and a magnificent celestial globe in which the sky was of gold and the stars marked in precious stones.

In the midst of this darkest epoch before the dawn, arose the famous scholar, Gerbert, afterwards Pope Sylvester II, the most eminent mathematician of his day, who was largely influential in introducing into Europe the modern arithmetical notation, which, supplanting the clumsy systems of Greece and Rome, was an absolute prerequisite for anything like mathematical progress. Richer's "Life of Gerbert" gives us the first reliable memoir of this remarkable man. A native of Auvergne, in Southern France, he early entered the monastery at Aurillac, but was sent while still a youth under the care of Borel, Count of Barcelona, to study in the Christian Schools of that district, which had profited by their proximity to Arabian seats of learning. Having made great progress in mathematics and Astronomy, Gerbert visits Rome, is flatteringly received by Pope John XIII and by him presented to the Emperor Otto I, who remained his great patron. Our great debt to Gerbert lies in his remarkable powers as an instructor, in the number and dignity of his pupils,—"half the prelates and princes of Europe having gloried in calling him Master,"—and in the general stimulus he gave to learning. His acquirements were varied and popularly supposed to include all knowledge. His specific services to science consisted in his introduction into arithmetic of the use of the abacus, which gave positional value to the nine digits, though without the zero, his development of geometry, his construction of astronomical spheres, astrolabes, quadrants and even clocks (regulated according to the movement of the polar

* Ingulphus: Tome I, p. 98.

star), and his indefatigable zeal in translating or procuring valuable manuscripts, for whose possession he sometimes exchanged his astronomical instruments.

Cajori, in his "History of Mathematics," and Smith and Karpinski in their "Hindu-Arabic Numbers," each enters into an interesting discussion as to the sources of Gerbert's arithmetical notation, the distinction between his "apices" and the Hindu numbers, as used by the Arabs of Spain, together with the interesting question as to whether oriental numbers could have been brought to Europe directly through Alexandria, even earlier than the Moorish Invasion. Gerbert claims to derive his mathematical knowledge from Boethius' Geometry, and it is upon our acceptance of the so-called "Pythagorean Tables" therein as genuine that our answer to the mooted point chiefly depends. Cajori regards it as most probable that the Alexandrians obtained the nine numerals from the Hindus about the second century A. D. and gave them to the Romans on the one hand and to the Western Arabs on the other (p. 83). While he distinctly adds, "It is argued by some that Gerbert got his apices, not from Boethius, but from the Arabs of Spain, and that part or the whole of the Geometry of Boethius is a forgery, dating from the time of Gerbert. If this were the case, then the writings of Gerbert would betray Arabic sources. But no points of resemblance are found" (p. 126). M. Chasles, as quoted by Humboldt, also inclines to a similar view.* Gerbert is said to have observed the stars through a movable tube, which some have supposed to be a telescope, but there seems no reason why it may not have been simply an open tube, used for purpose of orientation. Smith and Karpinski tell us that Gerbert's death connotes the passing of the *Dark* Ages, that, with the opening of the eleventh century, another era of revival began, showing itself chiefly in the translation of philosophical and mathematical works from the Arabic (p. 123). "The zeal," adds Cajori, "displayed in acquiring Mohammedan treasures of knowledge, excelling even that of the Arabs themselves, when, in the eighth century, they plundered the rich coffers of Greek and Hindu science" (p. 125). Gerbert's Geometry and his work on the abacus were read with avidity.

Three other works were also popular about this time: "De Mundi Coelestis Terrestrisque Constitutione Liber," once attributed to Bede but containing allusions to events as late as 814; the "Imago Mundi," by Honorius of Autun, an Augustinian hermit; and the "περὶ Διδαξεων, sive Elementorum Philosophia." This last is sometimes attributed to William of Couches and, if by him, was written somewhat

* Cosmos: Vol. II, p. 226, note 358.

later than the others, which may well be, as it shows more freedom of thought and less literalness in the application of Biblical texts to cosmogony. About 1116, Plato of Trivoli translated the astronomy of the Arab prince, Al Battani, which was that of Ptolemy, but with certain improvements and corrections, as in the use of the *sine*, in place of Ptolemy's chords, in trigonometry, as well as a limited use of the tangent. Thus these two functions were added to the increasing store of European mathematics. Euclid's Elements were now translated by Athelard of Bath, who "braved a thousand perils that he might acquire the language and science of the Mohammedans."

About the middle of the twelfth century, a little group of Christian scholars were busily at work under the leadership of Raymond, Archbishop of Toledo. Among them were John of Seville, who compiled a "Liber Algorismi" from Arabic sources, Robert of Chester, who translated the Algebra of Musa Al Hovarezmi, and Gerard of Cremona, who, with praiseworthy industry, attacked the Almagest itself and is credited in all with 70 translations from the Arabic. However, men were not content to study Greek authors simply through the Arabic. Already Frederick II had ordered translations of Aristotle from the Greek. Through the influence of the great Dominican scholar, Albertus Magnus [1199-1280], fresh versions were called for. Albert comments freely on the Stagirite, devoting one chapter to the latter's "Errors". In his "De Coelo et Mundo," Albert is said to have taught that the Milky Way is nothing but a vast assemblage of stars, though he imagines them to receive light from the sun. The spots visible on the lunar disk are not, he decides, reflections of the earth's surface, as Aristotle taught, but due to configurations of her own. He corrects Aristotle's statement as to the rarity of lunar rainbows, and has something to say on the refractive power of the sun's rays, as well as on the refractive power of crystals. As a geographer, he was far superior to his contemporaries, and incidentally, decidedly disapproves of Bede's idea of the uninhabitability of the regions south of the equator. His still greater disciple, Thomas Aquinas, was soon to write a direct commentary on Aristotle's "Book on the Heavens," which Dreyer considers the clearest yet produced.

Meanwhile the scholarly Frederic of Hohenstaufen had founded the University of Naples in 1224, partly to draw scholars from the then existing ones of Paris and Bologna to his own dominions, but ostensibly for the greater encouragement of natural science. Already Leonardo of Pisa, who completed the work Gerbert had begun, had written his "Liber Abaci" and "Geometria Practica", had been presented to Frederic by the astronomer, Dominicus, and had delighted that astonished

sovereign by his elegant solution of several algebraic problems, while the Monk, Lucas de Burgo, was formulating the rudiments of an algebraic symbolism.

Supplied thus with the meams of calculation, all seemed favorable for astronomic progress when again, the Hundred Year's War and the Black Death turned back for awhile the wheels of time. We must note however, in England, a great contemporary of Albertus Magnus, whom all schools of thought seem agreed to honour, the "Doctor Mirabilis," Roger Bacon (1214-1294). His vigorous mind and independent thought urged, as has often been observed, the need of direct experiment in science and the danger of undue adherence to authority. Many of his experiments, and possible discoveries, have been related. In astronomy, he wrote on the kalendar, concluding the anticipation of the equinoxes to be about one day in 125 years. In his work on optics he seems acquainted with the lens. He suggested various improvements in astronomical instruments and observations, while Admiral Smythe, in his "Bedford Catalogue", declares it beyond a doubt that his "extraordinary mind *conceived* the telescope." Bailly refers to a passage in Bacon's "Opus Majus" in which he alludes to the refraction of solar and lunar rays by means of convex glasses, and quotes a conjecture from M. de Caylu's "History of Ancient Astronomy" that the telescope may have been a discovery of antiquity whose tradition lingered on to the era of Bacon*. As a Franciscan Friar, Bacon fell under the suspicion of his superiors and was prohibited from teaching. On the election of Clement IV, formerly legate to England, to the papal throne, Bacon dispatched a messenger to Rome and placed his books and instruments in that Pontiff's hands. Clement's judgment was favorable, and it was at his suggestion that the injured friar made the collection of his works known as the "Opus Majus". With the election of his own General as pope, on the death of Clement, fresh difficulties, however, began. He was imprisoned, but recovering his liberty before his death, used the time for several farther writings.

Turning now to Spain, we find the astronomer king, Alfonso the Wise (1223-1284) occupied, at Toledo, on his famous tables. He gathered around him Jewish, Christian, and Mohammedan scholars, without distinction of race, or creed, and by 1252 the Alfonsine Tables were complete and continued to be of service to the astronomic world almost down to the time of Kepler. Alfonso wrote also the "Libros del Saber de Astronomia," a sort of Encyclopedia of the knowledge of the day in that science In it occurs a diagram representing Mercury's orbit as an ellipse. The editor of the Madrid edition of this work, Don Manuel

* Bailly: Histoire de l'Astronomie Moderne. Vol. I, p. 364.

Rico y Sinobas (1863), suggests, on page 33 of his preface, that Kepler may have seen this curve. Dreyer disposes of this suggestion by saying that the so-called ellipse is merely the resultant of a number of small arcs, and is obviously nothing but the curve described by the center of Mercury's epicycle on the Ptolemaic theory, the "sunlike" object in the center being only a "blot" caused by the stationary leg of the draughtsman's compass. Despite this explanation, the ellipse-like figure would certainly seem suggestive to any one in search of possible orbits, especially as this oval deferent of Mercury's orbit occurs in Purbach's "Theory of the Planets" (1460), while Albert of Brudzew (1482), in his "Commentary on New Theories", observed that the center of the lunar epicycle describes a similar figure. But whether or not Alfonso were able to improve on Ptolemy, he was certainly the first to venture to express open dissatisfaction with his theory, as his oft quoted remarks as to the good advice he would have given, had he been consulted at creation, plainly shows. We owe him also the rejection of the troublesome "Trepidation of the Equinoxes," a wholly needless and perverse complication which long haunted mediaeval astronomers.

In this same century, John Holywood or, in the Latinized terminology of the day, John Sacrobosco, an Englishman, but professor of mathematics at Paris, wrote an extremely popular handbook of astronomy which served to bring the system of Ptolemy within the reach of all. After the introduction of printing, it was published and passed through twenty-five editions between 1472 and the end of the century, and forty more by the middle of the seventeenth century*! It contained however nothing original.

We now approach a scholar quite commonly claimed as a precursor of Copernicus. Nicolaus of Cusa, the son of a poor fisherman, was born in 1401 at a little hamlet on the Moselle and educated at Deventer by the Brethren of the Common Life. Later he studied at Heidelberg and then, finding his way down into Italy, won his doctor's cap at Padua and lectured at Bologna. Here he found a congenial instructor in the great geographer, Toscanelli, the same who, still retaining in his old age the fire of youth, encouraged Columbus to seek a westerly route to the Indies. Cusa rose rapidly in the church. In 1431, he pleaded before the Council of Basle for the reform of the kalendar. Later he was appointed by Nicholas V, both Bishop and Cardinal. But it is to books II and XII of his "Docta Ignorantia" that we must turn for an exposition of his astronomical views. Cusa regards the universe as infinite and argues that the earth therefore cannot possibly occupy its center. Motion he believes to be natural to

* Berry: Short History of Astronomy p. 86.

all bodies, hence the earth must share in such motion. This is not contradicted by the evidence of our senses for we can only perceive motion by comparison with fixed objects. "How would one, in the middle of the sea, know that his ship was moving? The earth cannot be fixed, but moves like the *other stars*, wherefore it revolves around the poles of the world once in a day and night, as Pythagoras says." Other statements sometimes seem to confuse his meaning, yet these stand out plainly. Cusa also notes that no motion is "exactly circular", that the earth is not a perfect sphere; that straight lines produced to infinity may converge; that the sun, earth, and *other stars* are composed of the same elements, only differing in admixture and preponderance! He presents us with a view of the sun's constitution strangely akin to that once advocated by Herschel*. The obscurity of his writing on physical matters is heightened by the intermixture of philosophic and religious mysticism. But this much seems to have been quite generally extracted.

Germany and Austria now become for the time, the center of astronomic activity. Shortly after its foundation in 1365 the University of Vienna had become prominent in kindred subjects. Here Jean de Gmuden had taught and written on the kalendar, planetary motions, and the formations of certain astronomic instruments, dying in 1442. His work had been taken up by the elder Bianchini who continued the same routine. An abler scholar followed when, in 1450, George Purbach took the chair of mathematics and astronomy at the same university. He is indeed the first to whom Bailly in his "Astronomy of the Middle Ages" attributes any original work. Purbach visited Cardinal Cusa, then travelled in Italy and lectured at Ferrara, Padua, and Bologna. He revived the use of sines; computed tables of the same from 0° to 90°, introducing the decimal division, to replace the former sexigesmal division in its computation. Like Alfonso of Castile, Purbach, too, rebelled against the endless epicycles of Ptolemy. Especially his mind revolted against the assumed revolution of solid orbs around a mere mathematical point: a healthful sign that men's minds were gradually working towards the thought of gravitational forces. His own system, however, offered little to be chosen in preference to the great Alexandrine's, of whose Almagest he finally felt constrained to make a fresh translation.

Meanwhile, he had been joined by Johann Müller of Königsburg, whose name has descended to posterity disguised as Regiomontanus, and who, attracted by the reputation of Purbach, became his disciple at the youthful age of 15. When nine years later

* Deichmüller: "Die Astron. Bewegungslehre des Kardinals N. Von Cusa." Bonn 1901.

Cardinal Bessarion visited Vienna as papal legate, he found the two astronomers hard at work at their translation, but from a Latin exemplar. The Cardinal, himself a Greek, besought them not to waste their time on a Latin text, but to follow him to Italy, where they could obtain and study Greek originals. The sudden death of Purbach prevented his accepting this invitation. But his pupil, Regiomontanus, resolved to follow Cardinal Bessarion. In Italy he spent seven years in study and the collection of manuscripts. Returning home, he completed Purbach's "Epitome of Astronomy", but after a short stay at Vienna, removed finally to Nuremberg, where through the friendship and valuable coöperation of Bernard Walther, a wealthy burgher, he was able to establish an astronomical observatory: the first worthy the name, under European auspices. Here the newly invented art of printing was soon pressed into the service of astronomy. Among the books printed at Nuremberg none created a greater sensation than the Astronomical Ephemerides of Regiomontanus. They were the first publication of the kind in Europe, and were destined in a few years to guide the course of Columbus across the wide Atlantic, Regiomontanus having, among other things, invented a new method for ascertaining longitude at sea, that of lunar distances. In his "Tabulae Directionem" he expanded and perfected Purbach's trigonometrical works, calculating a table of sines for every minute and a table of tangents for every degree.

In the year 1472 a comet appeared which soon attracted the attention of the German astronomer, and appears to have been the first of its race to enjoy the honor of scientific study, or to be classed among truly celestial bodies, from which category the strictures of Aristotle had long excluded them. Finally, in 1475, Regiomontanus was invited to Rome to take part in the long desired reformation of the kalendar. Unfortunately for science he died, the next year, in that city, at the early age of 40, having been honored by the gift of the bishopric of Ratisbon before his death. Cajori characterizes him as one of the greatest men that Germany has produced. His friend, Walther, continued the work of the Observatory. He was the first to make use of the astronomical clock, now such an indispensable adjunct of observatory work, to measure the time of observations, the first also to make measurements as to the amount of atmospheric refraction with the object of correcting its effects.

More interesting, in the light of the now approaching discovery of Copernicus, is a theorem found among the mathematical papers of that universal genius, Leonardo da Vinci, demonstrating that a body moving in a spiral curve might approach a revolving globe, *such as the earth*, in such a manner that its apparent motion in

regard to any point on the surface, would appear as a straight line. Leonardo is also cited for his correct explanation of the reflected "*earthshine*" on the face of the new moon, often referred to as the "old man in the arms of the new."

A few minor astronomers, nearly contemporaneous with Copernicus, now meet us. Such are Apian (Bienewitz), who occupied himself with cometary observations, noting that a comet's tail always pointed away from the sun; Nonius, who solved several interesting problems on the duration of twilight in various latitudes; and John Fernel, who in 1528 made a new determination of the size of the earth, when he arrived at a result the error of which was less than one per cent, most creditable certainly considering the imperfect instruments of that day. Of Fracastoro and Amici, both living during Copernicus' life, little need be said since their peculiar and individual "systems" only serve to show the growing discontent with that of Ptolemy.

A time had now come when the astronomic world was ripe for a change. No farther progress along the old lines was possible. To the slow process of assimilation of ancient theories, with unbounded reverence for the great lights of antiquity, natural and even commendable in an age of comparative ignorance and immaturity, had succeeded a period of riper judgment which called for a new system, and Copernicus appeared to present his heliocentric theory! The work of his predecessors had been humble and hidden, yet it had slowly provided the prerequisites for that of the great Reformer. The assiduous reader of history must often note a distinctly variant attitude among writers toward the men and period of the Middle Ages. Some speaking of both with real sympathy, noting the various steps which marked their ascent toward fuller light. Others regarding mediaeval times as an absolutely starless night, whose darkness was only dispelled by the light of the renaissance, when men's minds were roused from their lethargy by the perusal of Greek literature. Yet it was precisely from such perusal, in matters scientific, that our mediaeval student needed to escape. Misled from the first by a false system, which became ever more complicated as his own observations grew more accurate, it was only by a complete *volte face* that reform was possible.

Naturally our estimate of the debt which he owed his Greek brother will depend largely on that we have framed as to the heritage the latter may, or may not, have received from the Orient. Here authorities differ widely, one tracing Greek astronomy to Egyptian and Chaldaic sources, others crediting the Greek astronomer with almost independent research. Dreyer regards the "Spheres of Callippus" and the "Epicycles of Ptolemy" as "elegant geometrical

schemes," and gives little credence to Egyptian acceptance of any heliocentric revolution of the planets such as that put forth by Tycho Brahe. Proctor, on the other hand, refers to the same as proven almost beyond a doubt. "I have, for my own part," he writes, "little doubt that the epicycle system of the ancient Egyptians and Babylonians was of the kind last described" [i.e. Tycho Brahe's]. The Greek astronomers could get no more out of this than the artificial, as well as cumbrous, system of Ptolemy. But there is strong evidence to show that among their sacred secrets, the older astronomers preserved the only natural epicyclic system, afterwards independently rediscovered by Tycho Brahe."* Where doctors so disagree, who shall presume to decide? However it be, the fact remains, that, when the great discovery came, neither to Greek nor Arab do we trace it, though each had been for a while the instructor of Europe, but to these same oft discredited sons of the Middle Ages, who though slowly, yet surely, laid the foundations whereon future generations might build, leaving both Greek and Arab behind in the race.

AN INVESTIGATION INTO THE INCREASE OF STAR-DENSITY AS THE MILKY WAY IS APPROACHED.

HECTOR MACPHERSON, M. A., F. R. A. S.

I. Introductory.

At an early stage in the history of stellar astronomy the crowding of the stars to the plane of the Milky Way was commented upon by astronomers practical and theoretical. As long ago as 1755 Kant pointed out the tendency of the brighter stars to aggregate in the Galactic region; but the elder Herschel was the first to demonstrate by observation the galactic aggregation. His famous "star-gauges" showed that, in his own words, "the number of stars increases very fast as we approach the "Via Lactea." Sir John Herschel's southern star-gauges confirmed his father's work. His gauges, he remarked, "show a gradual but rapid increase of density on either side of the Milky Way as we approach its course and the reproduction of nearly the same law of graduation on the north side which holds good on the south, so far as the comparative paucity of the gauges taken in that direction allow us to judge."

* Proctor: Old and New Astronomy, p. 165.

In his *Etudes d'Astronomie Stellaire*, published in 1847, Wilhelm Struve discussed the increase of stars as the Galaxy is approached,—his material being the catalogues of Bessel, Piazzi and others. Dealing with 52,199 stars, he tabulated the number of stars in each hour of Right Ascension. He found, to quote the words of Gore, "that the numbers increase from hour I to hour VI, where they attain a maximum. They then diminish to a minimum at hour XIII, and rise to another but smaller maximum at hour XVIII, again decreasing to a second minimum at hour XXII. As the hours VI and XVIII are those crossed by the Milky Way, the result is very significant."

In 1870, Proctor plotted on a single chart all the stars to the number of 324,198, contained in Argelander's great *Durchmusterung*. The result was, in his own words, that "in the very regions where the Herschelian gauges showed the minutest telescopic stars to be most crowded, my chart of 324,198 stars shows the stars of the higher orders down to the eleventh magnitude to be so crowded that by their mere aggregation within the mass, they show the Milky Way, with all its streams and clusterings." This was confirmed by Schiaparelli; and a later investigation by Gore showed that stars of each individual magnitude, taken separately, tend to aggregate on the Galaxy. The later work of Celoria, Seeliger, and others has abundantly confirmed the earlier researches.

It may be asked, therefore, why the following investigation should have been made at all. If the increase of the star-density towards the Galaxy is so well demonstrated, why make an independent investigation in order to confirm it? So far as I know, no survey of this kind has hitherto been made with so small an instrument, nor with so limited a a number of star-counts. The investigation is of interest simply in showing that even with slight optical assistance and dealing with star fields scattered at random all over the sky, the law of gradual increase of stars as the Galaxy is approached holds good.

II. Course of Investigations.

These observations on star-density have been continued during a considerable number of years. They were commenced in February 1904 and the instrument used throughout has been a 2-inch refractor.

The method of observation is very simple, as shown in Figure 1. The telescope is adjusted so that a given bright star is just on the edge of the field of vision as in (i). The number of stars is then counted. The telescope is then adjusted as in (ii) and the number of stars is again counted. This gives the number of stars surrounding the star. Accordingly, to give one example, the jotting in the observation note-book read as follows:—"Round Alpha Aquilae, 17 stars."

The regions chosen for observation were those round the brighter stars, mainly of the first three magnitudes. The greater number of the available stars of these magnitudes were observed, three determin-

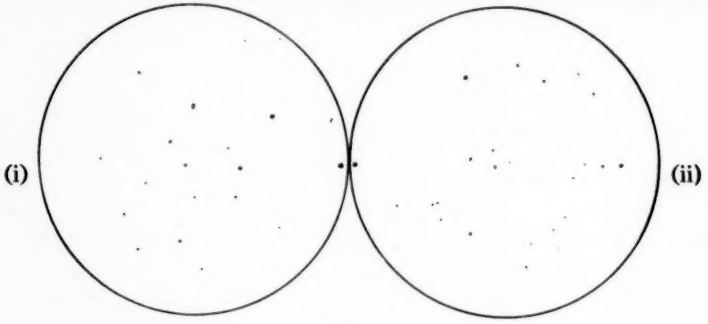


FIGURE 1.

ations being made. Observations were never made on moonlight nights, but even on moonless nights atmospheric conditions vary and this affects the number visible in the field of view. Accordingly a mean of the three determinations was adopted.

The investigations fall into three well defined stages.

(1) Observations were commenced in February 1904 and continued with more or less regularity until June 1906. They were then discontinued for a time, charts were drawn and the resulting star-counts were discussed in hours of Right Ascension.

(2) In 1907 I decided to discuss the results in Galactic Latitude, but found myself hampered by the absence of convenient tables for the conversion of one set of coördinates into another. I wrote to Professor Kapteyn for tables and he very kindly supplied me with one; it was, however, somewhat limited in its scope and I was able to utilize only a small proportion of the observations made. Nevertheless, the resulting graph brought out clearly the increase of star density as the Galaxy is approached and was sufficiently complete to be embodied in a paper read before the Astronomical Institution of Edinburgh in November 1909.

(3) For several years absorption in other work prevented me from taking up this work; but in the end of 1915 I came across more elaborate tables in a copy of the Groningen Publications which Kapteyn had kindly forwarded to me some time previously. Accordingly I undertook a rough reduction of the positions of all the stars I had observed to Galactic Latitude. In addition I checked carefully the results reached during the star-counting observations in 1904-6 and in 1908. In the spring of 1916 I undertook a rapid survey of regions

where the counts were divergent and also regions which had been missed in the earlier surveys. Thus I was enabled to utilize all the observations which had been made and to form a graph of the increase of star density in zones of Galactic Latitude.

III. Summary of Results.

In 1907 I discussed the results of my observations in hours of Right Ascension. The brighter stars—round which the counts were made—were arranged in order of Right Ascension, and the number of stars counted round each star was marked. In each hour of R. A. I noted the greatest number of stars observed in one region and the least number. The tabulation is as follows:

Hours of R. A.	Greatest No.	Least No.	Hours of R. A.	Greatest No.	Least No.
I-II	30	6	XIII-XIV	10	2
II-III	24	6	XIV-XV	10	2
III-IV	33	15	XV-XVI	15	4
IV-V	24	8	XVI-XVII	16	6
V-VI	46	6	XVII-XVIII	27	10
VI-VII	42	16	XVIII-XIX	39	12
VII-VIII	24	11	XIX-XX	50	16
VIII-IX	10	1	XX-XXI	44	4
IX-X	6	4	XXI-XXII	17	6
X-XI	11	5	XXII-XXIII	26	1
XI-XII	17	3	XXIII-XXIV	19	1
XII-XIII	7	2	XXIV-I	20	2

The maxima and minima numbers are shown in graphical form in Figure 2. The density is greatest in hours V-VI and VI-VII and XIX-XX

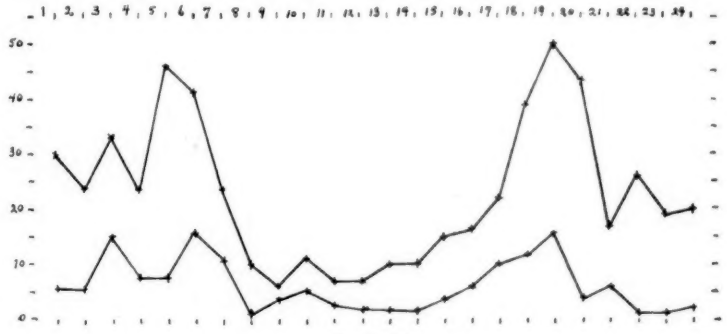
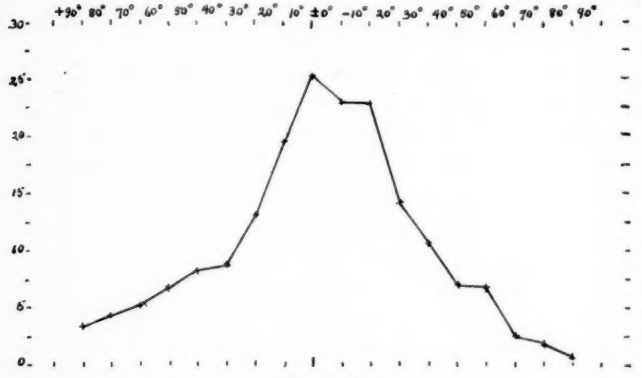


Figure 2.
Increase of Star-Density in Hours of Right Ascension.
Maxima and Minima Graphs.

As hours VI and XVIII are what may be called galactic hours—where the Galaxy most nearly approaches the vertical—the results are interesting.

It was not until the second stage in the investigation that I tabulated the results in order of galactic latitude, and for the reason already explained, the first discussion was a very approximate one, only a



FIUURE 3.
Graph of Star-Density in Zones of Galactic Latitude.

small proportion of the observations made being used. It was only in the spring of 1916 that I succeeded in making an exhaustive tabulation of the stars observed in order of galactic latitude. I divided the heavens into zones, each of ten degrees width, of galactic latitude. I did not form two tables, of the maximum and minimum number of stars observed in the regions round the brighter stars; instead the average number of stars in a region round the brighter stars was taken for each zone of G. L., and the result was as fol ows

Zones of G. L.	Average No. of Stars	Zones of G. L.	Average No. of Stars
+90° — 80°	3.5	±0° — 10°	23
80 — 70	4.6	10 — 20	23
70 — 60	5.6	20 — 30	14.2
60 — 50	7	30 — 40	11.2
50 — 40	8	40 — 50	7
40 — 30	8.6	50 — 60	7
30 — 20	13	60 — 70	2.5
20 — 10	19.5	70 — 80	2
10 — ±0	25.2	80 — 90	1

The result is shown in graphical form in Figure 3. In Figure 4 is shown the graph constructed from Seeliger's tables giving the star-density in regions of twenty degrees of galactic latitude. Seeliger's discussion, it is to be remembered, comprises over 100,000 stars.

The investigation, made with a small telescope on about 300 star fields scattered at random over the sky, harmonises in a remarkable way with the exhaustive and elaborate discussions and results reached

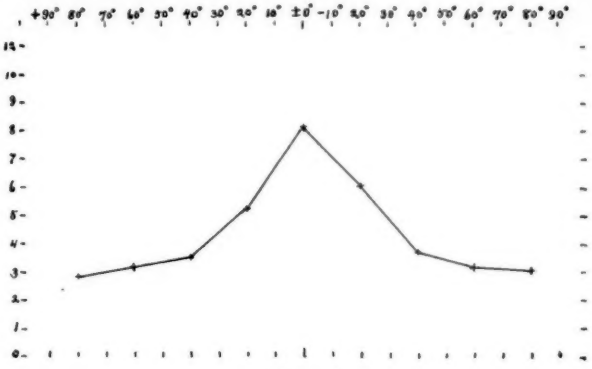


FIGURE 4.
Graph of Star-Density according to Seeliger.

by skilled astronomers. Because of this fact, it seemed to me that this account of a course of study pursued in student days with limited instrumental means might be of some interest.

NINETEENTH MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY.

[*Continued from page 38.*]

THE PARALLAX OF CERTAIN BINARY STARS.

BY HANNAH B. STEELE.

The part of the program most emphasized at the Sproul Observatory is the determination of the parallax of binaries whose orbits are fairly well known. The results for the twenty visual binaries so far investigated are given in the table. Data for fifteen other stars with parallaxes determined elsewhere were also discussed.

No.	Star	Mag.	Sp.	Parallax	Period in years	Semi-Major axis	Semi-Major axis (in AU)	Mass	Luminosity
1	Σ 3062	6.10	F	+0".030 ±0".008	105.55	1.44	41.14	6.25	5.53
2	η Cass.	3.64	F8	+0.182 ±0.009	327.87	9.48	50.70	1.21	1.87
3	20 Persei	5.6	F	+0.025 ±0.011	33.33	0.16	5.33	0.14	11.93
4	β 883	7.9		+0.003 ±0.013	16.61	0.19	23.75	48.56	20.17
5	ξ Cancri	5.6	F	+0.030 ±0.007	60.083	0.856	24.46	4.05	8.76
		6.3		+0.035 ±0.011					3.52
6	ε Hydrae	3.48	F8	−0.002 ±0.010	15.3	0.23			
7	Σ 3121	7.6		+0.078 ±0.015	34.00	0.6692	8.06	0.45	0.25
8	OΣ 235	5.47	F	+0.051 ±0.013	71.9	0.78	13.93	0.52	3.86
9	β 612	5.54	A	−0.016 ±0.013	23.05	0.225			
10	OΣ 285	7.1		−0.028 ±0.015	76.67	0.3975			
11	μ^2 Bootis	6.66	K	+0.054 ±0.011	219.42	1.2679	21.49	0.21	1.16
12	γ Cor. Bor.	3.93	A	+0.031 ±0.006	73.0	0.736	20.44	1.60	38.6
13	ζ Herculis	3.00	G	+0.086 ±0.007	34.530	1.355	14.89	2.77	14.2
14	70 Ophiuchi	4.07	K	+0.181 ±0.009	86.66	4.5227	24.32	1.91	1.27
15	β 648	5.21	G	+0.122 ±0.019	45.85	1.04	8.19	0.26	0.95
16	β Delphini	3.72	F5	+0.016 ±0.011	26.79	0.480	22.86	16.65	138
17	τ Cygni	3.82	F	+0.023 ±0.014	47.0	0.91	32.50	15.54	70.6
18	κ Pegasi	5.0	F5	+0.073 ±0.009	11.37	0.29	3.72	0.40	3.06
19	π Cephei	4.56	G	−0.020 ±0.012	198				
20	85 Pegasi	5.85	G	+0.101 ±0.008	26.3	0.82	7.74	0.67	0.76

REMARKS ON THE MOTION OF THE STARS IN AND NEAR THE DOUBLE CLUSTER IN PERSEUS.

By A. van Maanen.

In a previous paper Adams and myself announced the common radial velocity of nine stars in the neighborhood of the clusters h and χ Persei. The program was later extended to stars as faint as 9.1 mag.; of the 38 stars observed, 26 have common radial velocity of a little over 40 km/sec., of which nearly all must undoubtedly belong to the clusters; two are still doubtful, while 10 have quite different radial velocities. Of the 26 stars with common V, one has a large proper motion at right angles to the line of sight, viz., $>0''.3$, while the cluster stars have a very small proper motion. In discussing the proper motion of the cluster this star was therefore excluded.

For the determination of the proper motion at right angles to the line of sight it was supposed that the 25 stars showing the same radial velocity, belonged to the clusters and would therefore also have a common μ_α and μ_δ. Thanks to a large number of recent observations in right ascension, due to Fox and Mr. Max Peterson, we were able to derive a good μ_α. Fox and Peterson have reobserved with the Dearborn meridian circle the right ascension of 131 stars, viz., all the stars which were observed between 1860 and 1862 by Krüger and nearly all those which were measured by Miss Young on Rutherfurd plates, taken in 1874. I should like to acknowledge a grant from the Gould Fund of

the National Academy of Sciences, which enabled me to use a computer for the extensive reductions of these Dearborn observations. I am sorry to state that the material for the derivation of μ_δ was much less satisfactory, as only very few stars have been recently observed in declination. However, I have used the material available for this purpose.

The μ_α and μ_δ derived for the motion of the clusters are:

$$\mu_\alpha = + 0''.003$$
$$\mu_\delta = + 0''.003$$

It will be noticed that this motion is not in the direction of the Sun's antiapex, and it will therefore be impossible to derive the parallax of the clusters from their parallactic motion. This is not surprising for the clusters must have a considerable peculiar motion, as is clear from the large radial velocity of more than 40 km/sec., while the component of the solar motion in the direction of the Perseus cluster is only 5 km/sec.

The material available was then used to correct the relative proper motions formerly derived by me from plates taken at Helsingfors and Pulkova. These corrections, constant for μ_α and dependent upon the magnitude of the stars for μ_δ, were applied to the relative proper motions to derive the absolute motions of the 1418 stars measured. An investigation was then made of the motion of the stars, which likely do not belong to the clusters. For this purpose I excluded the stars near the clusters and also those whose radial velocities indicate that they belong to the cluster. These motions, arranged according to magnitude are given in the following table:

Mag.	μ_α	μ_δ	No. of stars	μparall.	μ_τ
	″	″		″	″
6.4 to 7.4	+0.016	+0.017	3	+0.001	+0.023
7.5 " 8.4	+0.059	−0.037	5	+0.069	+0.012
8.5 " 9.4	+0.023	−0.012	29	+0.025	+0.006
9.5 " 10.4	+0.004	−0.001	72	+0.004	+0.001
10.5 " 11.4	+0.007	−0.0025	153	+0.007	+0.003
11.5 " 12.4	+0.005	0.000	243	+0.004	+0.003
12.5 " 13.4	+0.006	−0.002	214	+0.006	+0.002
<13.4	+0.011	−0.006	46	+0.012	+0.003

From these mean μ_α and μ_δ for the different magnitudes we can derive the amount of the motion in the direction of the parallactic motion and that at right angles to it (τ).

It is clear that, except in the first case, where there are only three stars, the mean proper motions are practically in the direction of the Sun's antiapex. The deviations at right angles to the parallactic motion are all directed towards the motion in Kapteyn's first star-stream. This

may either be due to a systematic error or may mean that most of the fainter stars share the first stream motion only. Material for other regions of the sky can decide between these two alternatives.

Finally we may derive from these 765 stars, which most likely do not belong to the clusters, a corrected table of their distribution according to magnitude and proper motion. The results are collected in the next table. Material as in this table, showing the frequency of proper motion according to magnitude and amount of proper motion will enable us to solve some problems of the distribution of stars in space as soon as more material of other regions of the sky will be available.

Mag. / μ	6.4-7.4	7.5-8.4	8.5-9.4	9.5-10.4	10.5-11.4	11.5-12.4	12.5-13.4	<13.4	Total
0".000—0".009		2	3	26	47	69	63	7	217
0.010—0.019	2	1	11	29	53	99	87	22	304
0.020—0.029		1	7	6	34	43	43	9	143
0.030—0.039			1	7	14	19	12	4	57
0.040—0.049			1	1	4	10	5	1	22
0.050—0.059			2	1				1	4
0.060—0.069	1					1	1	1	4
0.070—0.079						1	1		2
0.080—0.089			2	1		1	1		5
0.090—0.099									0
0.100—0.149			1	1			1	1	4
0.150—0.199					1				1
0.200—0.249									0
0.250—0.299									0
0.300—0.349		1							1
0.350—0.399			1						1
Total	3	5	29	72	153	243	214	46	765

LUNAR AND TERRESTRIAL ALBEDOES.

By Frank W. Very.

An examination of the arguments by which Zöllner deduced his value of the lunar albedo has convinced me that they are not sound, and that the whole subject must be taken up afresh. At the start, Zöllner adopted the incorrect idea that the total spherical output of sunlight must be considered in arriving at the Moon's reflection. Had he considered only the *half* sphere of the Sun, which alone is visible from the Moon, his intricate argument, which Müller characterizes as "illusory", would not have been needed, for he would have arrived at once at the ratio of moonlight at the full to sunlight,

$$M_o = \frac{1}{2} A_2 \times \frac{\sin^2 s_o \sin^2 \sigma_o}{\sin^2 S} = \frac{1}{618{,}000},$$

where s_o, σ_o, and S are the semi-diameters of the Sun as seen from the full Moon, and of the full Moon and Sun as seen from the Earth, while A_2 is the geometrical albedo. If $\sigma_o = 15' 32''.7$, since $\sin^2 S / \sin^2 s_o = 1.00515$,

$$A_2 = 98{,}317 / 618{,}000 = 0.159,$$

and this is the correct reduction of Zöllner's own measures, instead of his so-called "true" albedo of 0.174.

By means of spectro-photometric measures, which have the advantage that they entirely eliminate the Purkinje effect, I have obtained the following ratios of sunlight to full moonlight throughout the visible spectrum:

λ	Sunlight : Moonlight	λ	Sunlight : Moonlight
μ		μ	
0.40	531,000	0.56	682,000
0.42	559,000	0.58	666,000
0.44	587,000	0.60	646,000
0.46	607,000	0.62	619,000
0.48	640,000	0.64	600,000
0.50	669,000	0.66	513,000
0.52	681,000	0.68	456,000
0.54	685,000	Mean	609,000

This gives me the value 681,000 : 1 for the rays which chiefly affect the eye, a number which differs little from Zöllner's. Russell's adopted ratio (465,000 : 1) may answer well enough for the infra-red, but is entirely too small for the rays which affect the eye. Bouguer's estimate (300,000 : 1) should be at least doubled to correct for the Purkinje effect. Various other widely aberrant values require large corrections for changes in atmospheric transmission which have not been applied and can not now be determined.

My published earth-shine observations need no correction, but the albedo of the Earth founded upon them involves the adopted value of the lunar albedo (which in this case was Zöllner's) and must be changed accordingly. Russell (*Astrophysical Journal*, Vol. 43, pp. 173-196) has unwarrantably rejected my measures of the earth-shine on the Slipher spectrograms (for which see *Astronomische Nachrichten*, 4819-20), and in attempting to introduce unnecessary emendations of his own, he has made a numerical blunder and has completely falsified my result. The "mean full Earth as seen from the Moon" is not "forty times brighter than the full moon," but *sixty-eight* times as bright. His assertions that my photographic corrections were unnecessary, and that my observation of the earthshine "far from being inconsistent with

Abbot's value of the solar constant (1.93 calories) is actually in agreement with it," were founded on this error and need no further refutation by me.

Since it is desirable to get some idea of the integrated, or spherical albedo (A_1), although this can only be estimated somewhat hypothetically (except in the case of the Moon, where the complete phase-curve is known) this quantity is also included in my final summary:

Geometrical albedo,	Moon	(Very),	$A_{m2} = 98{,}317/681{,}000 = 0.144$	} Mean
" "	Moon	(Zöllner),	$A_{m2} = 98{,}317/618{,}000 = 0.159$	} 0.15.
" "	Earth	(Very),	$A_{e2} = 4.8 \times 0.15 = 0.72$	
Spherical "	Moon		$A_{m1} = 0.35 \times 0.15 = 0.053$	
" "	Earth		$A_{e1} = 0.70 \times 0.72 = 0.504$	

Geometrical reflection of total radiation: Moon = 0.185, Earth = 0.60(?).

With Russell's adopted magnitude of the Sun (−26.72):

Stellar magnitude of Moon	(Very by comparison with Sun)	−12.14
" " " "	(Zöllner " " " ")	−12.24
" " " "	(Zöllner " " " Capella)	−12.18
Photographic " " "	(King, Russell's phase-curve, etc.)	−11.37
Moon's color-index	(King—Very)	+ 0.77

or a little less than that of the Sun, which agrees with Abney's photographic observations, confirmed by my spectro-photometric comparison of Sun and Moon, in showing that moonlight is bluer than sunlight, though it is also redder, but in a part of the spectrum which is neither photographically nor visually of much effect.

Earth's stellar magnitude, as seen from Moon, −16.72; from Sun, −3.77

THE SPHERICAL ALBEDOES OF THE PLANETS.

By Frank W. Very.

The spherical albedo (A_1) of a planet is the ratio of the total amount of light reflected by the planet to that which falls upon it from the Sun, and is obtained by multiplying the geometrical albedo (A_2) by the spherical factor,

$$q = \int_0^{\pi} \phi(\alpha) \sin \alpha \, d\alpha ,$$

where the reflective function of the phase-angle is $\phi(\alpha)$. By Lambert's law, $q = 3/4$, and by the Lommel-Seeliger law, $q = 3/2$. Russell, who adopts a "flat-disk" albedo which is one-half of the geometrical albedo, is obliged to introduce a factor 2 into his value of q (see *Astrophysical Journal*, Vol. 48, p. 178. eq. 7), but he has omitted to do so in getting his value of q by the Lommel-Seeliger law and has also integrated inaccurately, getting "$q = 1.6366$", instead of 3.0 as required by his equation (7).

Some of the planets (notably Venus, Jupiter, and Saturn) for which $A_2 > 2/3$, cannot possibly follow the Lommel-Seeliger law, which would give a spherical albedo greater than unity; but a derivative of this law for full phase coincides with the albedo on simple geometrical principles, and the law has other partial fulfilments.

The factor q is intimately related to the amount of the planet's atmosphere. For the heavily clouded major planets, q appears to be given by Lambert's law. Venus requires a modified mixture of the two laws. Müller's extrapolation to full Venus gives too sharp a peak to the phase-curve, since Venus does not reflect like the Moon. Two values are given in my table which are considered to be the greatest (1) and least (2) permissible ones. Russell's very convenient formula (*op. cit.*, Eq. 6) and the semi-diameters adopted by Lowell have been used in the reductions. The necessity for large color-corrections to the observed magnitudes of Uranus and Neptune is indicated and is confirmed in the case of Uranus by Lampland's photograph.

PLANETARY ALBEDOES.

Planet	Observer	Comparison body	Phase and distances	Stellar magnitude m_0	For D = 1, Δ = 1				
					Reduced Mag. g	Semi-diameter σ_1	Geometrical Albedo A_2	Spherical factor q	Spherical Albedo A_1
Moon	Very	Sun	Mean Opp.	−12.14	+0.81	2.″40	0.143	0.35	0.050
"	Zöllner	"	" "	−12.24	+0.71	"	0.157	"	0.055
"	"	Capella	" "	−12.18	+0.77	"	0.149	"	0.052
Mercury	Müller	Std. lamp	mean D, Δ = 1	− 2.77	−0.70	3.78	0.234	0.35	0.082
Venus (1)	"	" "	"	− 4.59	−3.88	8.48	0.864	0.70	0.605
" (2)	"	" "	"	− 4.46	−3.75	"	0.773	0.75	0.580
Mars	"	" "	Mean Opp.	− 1.79	−1.29	Eq. 4.68	0.261	0.55	0.144
Jupiter	"	" "	" "	− 2.23	−8.93	96.03	0.707	0.75	0.530
Saturn	"	" "	" "	+ 0.88	−8.67	77.74	0.849	0.75	0.637
Uranus	"	" "	" "	+ 5.86	[−6.45]	34.49	0.558	0.75	0.409
Neptune	"	" "	" "	+ 7.66	[−6.05]	34.56	0.461	0.75	0.346
Earth	Very	Moon			−3.76	8.79	0.720	0.70	0.504

EXAMINATION OF "NEW EVIDENCE" ON THE SOLAR CONSTANT.

BY FRANK W. VERY.

A reader of the paper in the *Smithsonian Miscellaneous Collections* (Vol. 65, No. 4, pp. 1-55) "New evidence on the Intensity of Solar Radiation outside the Atmosphere," by Abbot, Fowle, and Aldrich, is liable to infer that the question of the solar constant has been definitely settled by these authors. Unfortunately for this decision, the results given will not bear critical examination. Passing over the first part

of the Smithsonian paper which is mainly devoted to theoretical discussion, and confining our attention to the high level solar observation obtained by a self-recording thermograph carried by a sounding balloon, it should be noted that the instrument is a faulty one, as I pointed out in letters to Mr. Abbot which are quoted with some omissions (*op. cit.*, pp. 36-37). In an undertaking as difficult as this, we can pardon considerable instrumental imperfection, but not the totally incorrect reduction of the observations.

Notwithstanding the confidence with which this result is announced and the claim that it settles the question of the solar constant in favor of a value less than 2 cal./sq. cm min., the experiment, on the contrary, proves conclusively that the true value to be drawn from the reading in the balloon ascension is nearly 3 instead of 1¾, and therefore that the constant exceeds three calories. This very serious error follows on account of a local application of heat which was resorted to in order to keep the mercury in the thermometer from freezing. But I find from experiments with a similar apparatus that the Sun readings under these circumstances *are much too low*, and that a correction of over + 50 per cent is required on this account alone. When this large correction (whose necessity was unknown to the observers) is applied, the corrected result confirms the one which I obtained (*Astrophysical Journal*, Vol. 37, pp. 25-30) from M. Violle's records, which were the first to be obtained by the aid of the sounding balloon, namely 2.86 cal./sq. cm min. at 13.7 km. The two results, which are the only ones of the sort on record, are mutually confirmatory, at least in respect to the order of magnitude in question, and are in a very fair agreement with the presumption that the solar constant is about 3.6 gram calories per square centimeter per minute. The latter value is practically established as a minimum figure by the experiment described in the following paper.

PLANETARY EVIDENCE IN RESPECT TO SOLAR RADIATION.

By Frank W. Very.

1. From Müller's observations of Jupiter's stellar magnitude between 1878 and 1890, or through a sunspot cycle, there was a consistent increment of brightness from $b = 7.0$ to $b = 8.7$ between minimum and maximum of spots, followed by a similar continuous decrement of brightness from $b = 8.7$ to $b = 7.2$ in the succeeding period of diminishing sunspots, indicating that possibly the illuminating power of the Sun was 23 per cent greater at a time of maximum sunspots than when spots were few. Though the increment of total radiation, which would be given by an actinometer, may differ from

this fraction, and while the precise numerical value may require correction for changes in Jupiter's cloudiness, the general trend of the change of brightness coincides with that deduced from terrestrial meteorology in my paper on "The Variation of Solar Radiation" (*Astrophysical Journal*, Vol. 7, pp. 255-272). Jupiter is especially fit to serve as an arbiter in regard to such a change, because a large part of his surface heat seems to be produced internally; and thus the evaporation of water and the formation of cloud are not as dependent on solar heat as they are on the terrestrial planets. The argument is rendered stronger by Lowell's discovery that Saturn does not rotate as one piece, but has "confocal layers rotating faster within." Jupiter is presumably similar in this respect and generates internal heat by friction of layers of unequal velocity.

2. The polar snows of Mars appear to melt somewhat more rapidly and more thoroughly in summer at a time of maximum sunspots, but the evidence of solar change is not as consistent as the preceding, and conflicting activities are probably at work as on this Earth, where the effects of the solar cycle have only been detected with difficulty.

3. From my measures of solar radiation and the Moon's albedo, I infer that a surface temperature of 500° Abs. C. would be possible at the subsolar point if equilibrium could be attained. The actual temperature of 450° Abs. C. indicates that complete equilibrium has not been reached after one week of insolation.

4. After many attempts, I have succeeded in making a horizontal solar hot-box which appears to approach maximum efficiency, and which generates from the combined radiation of Sun and sky, by the heat-trapping influence of the Earth's atmosphere and of the cover of the box, a temperature of 423° Abs. C., capable of producing from blackened copper a radiation of 0.0302 C. G. S. units out of a 50 per cent delivery of the Sun's rays—this being all that can be allowed according to the measurement of the Earth's spherical albedo given in my first paper. Twice this quantity gives

3.62 gram calories per sq. cm per min.

as a first approximation to the solar constant.

THE RADIANT PROPERTIES OF THE EARTH FROM THE STANDPOINT OF ATMOSPHERIC THERMODYNAMICS.

By Frank W. Very.

In the great tropical and warm temperate zones of the Earth, most of the surface heat passes to the atmosphere by convection or radiation. The radiant properties of the Earth are thus mainly those of its atmos-

phere. It has remained for a member of this Society, Professor Frank H. Bigelow, to assure us that thermodynamic principles must henceforth be applied to meteorological problems. To this I would add, that quantitative measurements of the radiant properties of the atmosphere, which have been somewhat maltreated by Bigelow, can by no means be neglected.

The application of the thermodynamic equations of the books to conditions for which they were never intended, requires a complete restatement of fundamentals. The results obtained can not have the same rigorous certainty which applies to those of engineering practice; but this is a fault which is shared by nearly every other department of meteorology and solar physics. A few points may be briefly noted:

1. In a section of the free air, we must consider definite volumes, but they are contained in leaky compartments. The amount of leakage and the thermal transfers involved may be inferred from the deviations from adiabatic conditions.

2. The curve of density in its variation with the height, agrees perfectly with the curve of change of radiant potential in a vertical direction produced by molecular exchanges of radiation. In the lower air there are departures from gravitational equivalence of density and pressure which are due to absorption of extraneous radiation.

3. There is great ionization by the Sun's ultra-violet rays at high levels in the atmosphere, whereby much solar radiation disappears. Absorbent substances are generated thereby, and through their absorbent action the heat of the isothermal layer is produced. There is also an increase in the second differential of thermal interchange on entering the isothermal layer which conforms to this local development of thermal energy. I have determined the increase of thermal energy stored in the isothermal layer and find that there has been approximate doubling of heat (2.11 : 1.00) by this protective mechanism of the atmosphere (*American Journal of Science* **35**, p. 386, April 1915). Bigelow reaches the same ratio in another way and finds that "the isothermal region radiates 2.11 times as much heat as does the convectional region" ("A Meteorological Treatise on the Circulation and Radiation in the Atmospheres of the Earth and of the Sun" John Wiley and Sons, New York, 1915, p. 288).

4. The lower atmosphere shows a local production of atmospheric heat which must be attributed to absorption of *terrestrial* radiation by the moisture-bearing layers. This does not have much effect on the second differential of thermal interchange, apparently because the energy is used in another way, namely, in producing vertical motion of convection.

5. At every level there are cross-currents which equalize local abnormalities.

The increase of temperature in the isothermal region polewards between latitudes 40° and 70°, where the diminution of the radius vector per degree of northing (or *vice versa* for the S hemisphere) is especially large, is explained as produced by air from the tropic high-pressure belts, moving polewards, which retains its planetary momentum of rotation and overruns the lower layers, carrying moisture into the upper air where the absorbent power of this substance, and of its ionization products, serves to greatly increase the heat given by absorption of the Sun's rays. Calculation shows that 400 gram-calories, the accumulation of between two and three days of sunshine, are, on the average, retained by each vertical column of 1 sq. cm section between top and bottom of the atmosphere, and that the air radiates at about one-third of the rate of a black body of the same temperature, but from layers of limited depth, and changes temperature in large masses slowly on account of the innumerable transfers required.

THE TULSE HILL OBSERVATORY DIARIES.

By Sarah F. Whiting.

Six diaries, the record of the current work of the Observatory of Sir William Huggins from 1866 to 1899, were sent to the Wellesley College Observatory with the many rare gifts bequeathed by Lady Huggins.

These books further reveal the perseverance and self sacrifice as well as ingenuity in the pursuit of truth, of the pioneer in the new astronomy and of his gifted wife. Three of the books give a record of the work of the Observatory from evening to evening, the others of daytime experiments in the laboratory necessary to interpret the observations.

The reader realizes why Lady Huggins once remarked that Astronomy is a heart-breaking science to pursue under English skies, and wonders at the results achieved. Countless times it is recorded: "We opened the observatory in hope of clearing skies, to close it in disappointment." Astronomers now state glibly the elements to which this and that line in a star spectrum is due. To Huggins all was unknown, and the diaries show that he spent nights and days to make sure that he announced no discovery unsupported by clear evidence.

The Hugginses spent night after night trying to match the green nebular lines, sometimes almost believing that the manganese lines were co-incident; then with new apparatus of larger dispersion, they would find them yet of unknown origin.

The first book, started by William Huggins when about thirty years old, has upon its title page quotations of poetic beauty about the stars, in six languages.

The second goes on to record the observations of an amateur who was a keen observer, and an ingenious designer of apparatus. A list of visitors soon begun shows all the great names of the period in astronomy, revealing that Huggins was early received into the brotherhood of astronomers.

It is quite thrilling to find in these books the earliest records of the now highly developed astrophysics.

After Dr. Huggins' marriage, in 1874, the records, illustrated by fine drawings, are in the hand of his wife. It is manifest that she took all the spectral photographs, that she shared all the daytime and night observations.

All in photography was untried, and their labors in finding proper plates, proper times of exposure, proper developers, are manifest.

In 1889, they record increased interest in attempts to get a photograph of the spectrum of the Andromeda Nebula, because they had just received a photograph from Dr. Roberts showing that the nebula was a spiral system. "This photograph", they record, "gives the body; if we can get the spectrum, we shall have the soul."

The record of work on various comets and on Nova Aurigae reveal their devotion even when ill, and when they had to watch for hours just to obtain glimpses of their object between clouds.

These books show how closely related Sir William and Lady Huggins were in their work. Lady Huggins would record, "W. observed and without announcing his results, I repeated." Or Sir William records, "Madge threw in the comparison spectrum for a while, and I observed for coincidence and then we reversed. Our conclusions were the same." Lady Huggins once recorded, "We have not accomplished all we intended, for all the work of taking and measuring the plates is done by our two pairs of hands." There is no evidence that they ever had assistance of any kind, except from the instrument makers.

REPORTS OF COMMITTEES

FINAL REPORT OF THE COMET COMMITTEE.

By George C. Comstock, Chairman.

Supplementary to its report presented at the Evanston meeting, the Comet Committee begs further to advise the Society that its printed report has been received from the publisher and has been distributed

to the members of the Society and to a selected list of observatories and observers. The Smithsonian Institution having declined to receive for transmission packages destined to points within the European War zone, those copies of the report intended for delivery in such places have been retained and, in their addressed wrappers, are held by the Chairman of the Committee. In addition to these, about 175 additional copies of the report are in the hands of the Chairman. A financial statement accompanies this report and shows a credit balance of $3.38 due from the Society to the Chairman of the Committee.

The Committee having substantially completed its work requests to be discharged and recommends that the Society by appropriate action prescribe the way in which distribution of its report shall be completed and the disposition that shall be made of the unallotted copies of the report. (See Vol. 24, p. 582).

REPORT OF THE COMMITTEE ON STELLAR PARALLAXES.

By Frank Schlesinger, Chairman.

Last year this Committee compiled a complete report of its proceedings, including a list of 1871 stars that are under observation for parallax at one or more of the coöperating institutions. On account of its length this report was not included in the regular report of the 1915 annual meeting; but the report has been printed in full and reprints of it have been distributed to those astronomers who are more directly interested. It will be distributed to all the members of the Society as part of the Volume 3 of the Society's publications. A similar report has been compiled this year, and will be distributed in the same way. It includes additions to the observing lists, a memorandum of published results during the year, and a list of objects that have been abandoned for one reason or another, as well as a report of the progress made at the several observatories taking part in this work.

REPORT OF THE CHAIRMAN OF THE COMMITTEE ON PHOTOGRAPHIC ASTROMETRY.

By Frank Schlesinger, Chairman.

The calculations for the zone catalog of about 7200 equatorial stars, compiled by means of the three-inch wide-angle doublet at the Allegheny Observatory, are now practically complete. It has been decided to delay publication for a few months in order that the spectra of the stars may be included, Professor Pickering having very kindly offered to place these in our hands in advance of the publication of the new

Draper Catalog. The members of the Committee have discussed among themselves and with other astronomers the advisability and the feasibility of extending the zone catalog to include all or most of the sky, thus completing the duplication of the Gesellschaft Catalog that was contemplated forty years ago as part of the whole undertaking. Experiments are under way both at Oxford and at Allegheny, by members of this Committee, with the object of extending photographic determinations of star places in the direction of absolute determinations.

REPORT OF THE COMMITTEE ON METEORS.

By P. G. Nutting, for the Committee.

The meteor recorder which Professor Abbe planned to use consisted essentially in a circular horizontal photographic plate with lens on the zenith axis, an exposure lasting the night through. One objection was that a highly sensitive plate would be fogged by the diffuse light of the sky.

Our present plan is to photograph on highly sensitive film, renewed each minute, using a sort of enlarged and simplified motion picture camera. Such a camera has been designed by Mr. Folmer of the Century Camera Works and approved by Mr. C. W. Frederick, Dr. F. E. Ross, and myself, all of this Society.

Data would be obtained as follows:

1. Angular position and direction of trail from stellar images.
2. Parallax and distance from difference in angular position in images taken, say, five miles apart.
3. Velocity from duration and parallax. The beam to be interrupted five times a second by a sector shutter just behind the lens.
4. Time of appearance by photographing a clock-face in the corner of each picture; this approximate time (to one minute) with the position identifies each trail. Professor Abbe mentioned as desirable the recording of the time of appearance and disappearance to a fraction of a second, but does not state for what reason.

It would appear very desirable to bring the matter to an issue at the next meeting of the Society. If men will agree to operate these meteor cameras, we will agree to construct them to do the work required, the expense being met from some special fund.

REPORT OF THE COMMITTEE ON STANDARD EQUINOXES.

By Philip Fox, Chairman.

At the Cleveland meeting, the Chairman of this Committee suggested to the Council that the Society should urge the adoption of standard equinoxes in publications involving star positions. This was, of course, no new suggestion; but has been brought forward from various sources, most forcibly perhaps by Ristenpart as a result of his experience and tremendous labor in the Geschichte des Fixsternhimmels Bureau of the Berliner Akademie. In order to facilitate the adoption of standard equinoxes, he suggested the selection of 1925 and computed tables for the reduction from various dates to this equinox. These were published by the Observatory of Santiago de Chile. These tables are given also for each year in the Berliner Jahrbuch.

At the San Francisco meeting, this matter was again brought forward in a letter to the Council, from which the following quotation is made:

> "In all sorts of astronomical publications the star positions are given, and for a great variety of equinoxes. Following Burnham, many double star observers use 1880. Others, following the example of Aitken and Hussey, have adopted 1900. And still other dates are in use. In other fields, a tremendous variety of equinoxes are to be found. Even in the A. G. catalogue, there are three equinoxes in use, 1875, 1900, and 1905. For the purpose of pointing the telescope, intervals closer than fifty years are not necessary; and for the discussion of star positions, a vast amount of labor could be avoided if the multiplicity of equinoxes might be reduced to few.
>
> "For the purpose of opening discussion, I propose the following resolution:
>
> "THAT in the future, the members of the American Astronomical Society, in giving star positions, shall adopt no date intermediate between 1900 and 1950, and if possible that the Society may persuade foreign astronomers to adopt the same practice.
>
> "THAT the next equinox to be adopted for general use shall be 1950. Philip Fox".

At this meeting, a Committee was appointed with the following personnel: Messrs. Fox (Chairman), Eichelberger, Leuschner, Schlesinger, Eric Doolittle. The Committee was given power to add to its number, and accepting this power, the Committee has invited the Astronomer Royal, Mr. Dyson, and Mr. R. T. A. Innes to serve.

The Chairman circulated a letter to the various members of the Committee, in which the suggestion made in the original letter was modified as follows:

> "I am inclined to believe that the suggestion that we adopt no date intermediate between 1900 and 1950 might be modified, and that we should adopt at this time the equinox 1925. The Ristenpart tables will facilitate this reduction. I still personally believe that it would be better to adopt no equinox between 1900 and 1950; but it may be easier to unite on the intermediate date."

Replies were received from members of the Committee, and the following extracts are taken from them.

> *Schlesinger.* There is no question that the present custom of astronomers, the adoption of an equinox near the middle epoch of their observations, is a very wasteful one. In the preparation of our zone catalog of 7200 equatorial stars, compiled with a small doublet, I adopted 1875 as the equinox in spite of the fact that the epoch of these observations is forty years later, I can see no disadvantage that outweighs more than the merest fraction of the very obvious advantages.
>
> My opinion is that for the present, this Committee should restrict its action to the recommendation of three equinoxes, of which only one is in the future; 1875, 1900, and 1925. When peace is declared in Europe, the Society should ask the Astronomische Gesellschaft, the Royal Astronomical Society, and the Société Astronomique to appoint similar committees to act with ours and to agree if possible upon a procedure that will apply to all observations in the future, perhaps the adoption of 1925, 1975, 2025 etc. I therefore move that this Committee present to the Society for action the following resolution:
>
> WHEREAS, the use of many equinoxes for the publication of star positions has entailed a large amount of unnecessary computing,
>
> RESOLVED that the American Astronomical Society urge its members to refer their observations to one of the following equinoxes to the exclusion of all others: 1875, 1900, and 1925.
>
> *Eichelberger*: I have been mulling over your suggestion and talking about it. I have found just as many different opinions as to what should be done as I have consulted different persons.
>
> Neither your original motion to hold to 1900 until we go to 1950, nor the suggestion to substitute 1925 for 1950 appeals to me.

If any action is taken, I suggest that a tentative scheme be formulated and that the Astrophotographic International Committee according to whose suggestions most of the meridian circle work of the world is now being carried on, be consulted before final action is taken.

It seems to me that possibly the following set of equinox dates may be the most advantageous: 1900, 1920, 1940, 1960 etc., for if Greenwich, for instance, cannot be induced to conform to the new dates, no greater confusion will be introduced as the dates suggested are included in those now on the Greenwich list, and further, as Pulkowa has been issuing its fundamental catalogues at twenty year intervals, it might more readily adopt the suggested scheme than one made upon a different interval.

Doolittle: The matter mentioned in your recent favor seems to me to be of the very greatest importance, and if it shall be by any means possible to secure a practically universal acceptance of a standard equinox for star places, an immense amount of wholly unnecessary labor will be saved for us all. As you know the epoch 1880.0, now chosen for all double stars, is rapidly growing out of date: epochs of 1900, 1910, and even 1920 are separately chosen by discoverers, besides a few other dates, and this in one restricted department of our science alone. It is so all along the line, and I am sure everyone would welcome an attempt to secure a greater uniformity, even if this was not wholly successful. Every convert to the standard equinox, (whatever it may prove to be), would lessen the labor of whoever used the results in that particular case.

Of the two dates mentioned by you, I would unhesitatingly and strongly favor 1950.0. This date is already nearer us than the epoch 1880.0, and it seems to me is quite near enough. Of course, 1900.0, and 1910.0 are already out of the question, and extended works whose completion will take several years more will have been published but a short time before 1925.0 will have come. I feel quite sure that for double star purposes, fifty year intervals are small enough: it seems to me that anything much less than this serves only a temporary purpose.

Crawford: If an outside opinion will be of any avail, I should like to express mine as being in favor of the 1925 equinox.

Dyson: Although I am in sympathy with the idea of bringing out star catalogues to the epoch 1925.0, I am afraid it is not possible for me to join your committee. It happens that a catalogue, for which I am responsible, will be brought out for equinox 1910.0. The arrangements were made and precessions

computed years ago, and I am not prepared with a diminished staff to alter this now. It would, therefore, be inconsistent for me to join your Committee.

Innes: I am in receipt of your letter of the 24th of June last enclosing a copy of your circular letter on the adoption of a uniform equinox and your proposed motion.

Just amongst other things—for double stars I could not use 1880 because the Cordoba Catalogue and the C. P. D. were for 1875 and the latter gave 25 years' precession offhand: 1900 was therefore easier than 1880.

You say that for the purpose of pointing the telescope, intervals of 50 years would suffice. This is so for bright objects, but for faint objects I think 25 years is long enough. But for rough purposes almost any equinox would suit because it is so easy to apply approximate precessions. The difficulty comes when one requires places of the utmost precision.

You will have seen by my recent papers on the determination of proper motions with the blink microscope—including U.O. Circular No. 35 now being issued, that I am changing my point of view somewhat.

At present, I feel we ought to consider each *Carte du Ciel* region as an entity and catalogue with all precision the places of say eight stars of the 9th magnitude and without large proper motion as the reference stars which fix the *position of that area with reference to our moving equinox and equator.* Of course, we must use the brightest stars as intermediaries, but the number of those can be very strictly limited. Beyond this program, we require no places of precision. The photographs and the blink microscope do the rest.

The essence of my advocacy is that we adopt as our framework of reference, not the brightest and nearest stars, all in more or less discordant motion, but the fixed fainter stars.

If, however, astronomers insist on enormous catalogues of precision, then the only logical and economical device is to adopt a fixed set of coördinates such as a Galactic System, and I have shown that essentially it is as convenient to compute to or from as any other system.

If I could reply more definitely and you indicate on what lines, I will willingly do so.

Pickering: We are constantly using the epoch of 1855, which is now as distant as 1975, and in twelve years will be as distant as 2000. 1875, a nearly universal epoch, is more distant than 1950. I fear, however, that compilers of precise posi-

tions of the stars would find it difficult to carry forward their positions, not only from the necessity of using the third, or even the fourth term, but also owing to the unknown proper motions. It is so usual to publish positions for the beginning of the year in which they were observed, that strong objections will be made to a long interval. Even in photographic work with doublets, where we use the positions for 1900, and set directly by the circles, the deviation of the required region from the center of the plate is troublesome. Accordingly, it would seem that 1925 would be best suited to our needs for the next twenty years, and then that the epoch of 1950 could advantageously be adopted.

It would be a good plan for the Committee to send to a hundred selected astronomers a statement of the advantages of each different date. Their replies would doubtless have great weight. Perhaps a distinction should be made between catalogues giving precise positions and those giving physical properties; also, between catalogues which would require many years in their preparation and those made up at once from existing material.

A very useful catalogue might be prepared by the Committee of four or five thousand stars, perhaps including those of the magnitude 6.00 and brighter, giving the precise position for the adopted date, proper motion, parallax, radial velocity, photographic and photovisual magnitude, and class of spectrum. Other constants, such as galactic longitude and latitude, might also be included. The catalogue might include stars of special interest, as those having large parallaxes or motions. It might be useful work for the society to preserve such a catalogue in type and secure specialists who would keep the constants up to date each year. For instance, a compilation of the best results for parallax and radial velocity, brought up to date would be extremely convenient for investigators by statistical methods.

The replies show practical unanimity for the desirability of adopting standard equinoxes though there is naturally divergence as to actual dates suggested.

In view of the suggestion of 1950, it seemed necessary to locate someone who would undertake the computation of tables similar to those of Ristenpart, if the plan were to be at all feasible. Following this idea the Chairman consulted with Professor Malcolm McNeill, of Lake Forest University, who, after consultation, expressed his willingness to undertake the computation of such tables; so if and when the Society sees fit to adopt this plan, assistance will be available to further its realization.

At the Swarthmore meeting, this whole matter was discussed by the Committee, but rather briefly; however, they came to a conclusion which was adopted by the Council and recommended for practice by members of the Society:

> *"THAT in any publication involving star positions, no equinox should be used intermediate between the years 1900 and 1925."*

It is hoped that this restriction, which will greatly reduce the amount of labor now involved in the treatment of star positions, will find universal adoption by members of the Society and observatories of the country, and that eventually it may extend even farther.

At the Albany meeting in the summer of 1917, the Society will give this matter further consideration. In the meantime, if any member has suggestions bearing on this matter, the Chairman would be very happy to receive them.

NOTE ON SELECTION OF COMPARISON STARS FOR STELLAR PARALLAX DETERMINATION.

J. H. PITMAN.

The writer presented a paper on the above subject at the August, 1916, meeting of the American Astronomical Society. An abstract of the paper appeared in the January, 1917, issue of Popular Astronomy. It was recently noticed, while bringing to date our card catalog of parallax determinations, that Lal. 10299 was so close to Weisse 5^h592 that the two stars were probably on the same set of plates. This was at once verified and for that reason this note appears.

The work which really started investigation of the parallax of the comparison stars was the Sproul Observatory determination of the parallax of Weiss 5^h592. This star was among the first to be reduced here and was taken in order to compare the values obtained with the Sproul telescope to those obtained elsewhere. When all the necessary photographs had been made, measured and reduced, a parallax of $-0''.07$ was found instead of $+0''.20$, approximately as other observers had obtained.

The measures were given to the writer for investigation, not only of the measures themselves but also of the reduction, as it was thought some error had been made. No error was found here. Then all the plates were oriented the same as the standard plate to see how the

individual measures compared. It was then found that the comparison stars numbered 1 and 7 had large parallaxes, that of the former being about $+0''.2$ and of the latter about $+0''.08$.

This looked suspicious. The next step was to compare the chart used at the telescope with star catalogue positions. It was found that the star which had been placed in the center of the field and whose parallax had been determined was not Weisse 5^h592 but B. D. $-3°1118$, the right ascension of which was just 1^m less than that of the former. The comparison star designated as 1 was identified as Weisse 5^h592. Star marked 7 was a B. D. star but, as mentioned above, it was only recently that we noticed that this star was the same as Lal. 10299. The parallax of this star was determined by Smith with the Heliometer and Adams by his spectroscopic method. Both obtained $+0''.1$.

If in the same field, we have unknowingly photographed two stars with large parallaxes and picked these out from the measures of the comparison stars and the results have been confirmed by independent investigations, why might we not expect to find other close neighbors by this method?

Sproul Observatory,
January 5, 1917.

PLANET NOTES FOR MARCH 1917.

The sun will move from 7° 41′ south of the equator to 4° 3′ north of the equator during the month of March. On the twentieth of March the sun will cross the equator. At the time of crossing the equator the right ascension of the sun will be $0^h\ 0^m\ 0^s$, as this is the point from which right ascension is measured. This is the date of the vernal equinox, the beginning of spring.

The phases of the moon for the month are as follows:

Full Moon	March 8	at 4	P.M.	C.S.T.
Last Quarter	16	" 7	A.M.	"
New Moon	22	" 10	P.M.	"
First Quarter	30	" 5	P.M.	"

Mercury will be in the constellation of Capricornus. It will not be in a favorable position for observation at any time during the month, being too near the sun.

Venus will move eastward from the constellation of Aquarius into Pisces. It will not be visible during the month.

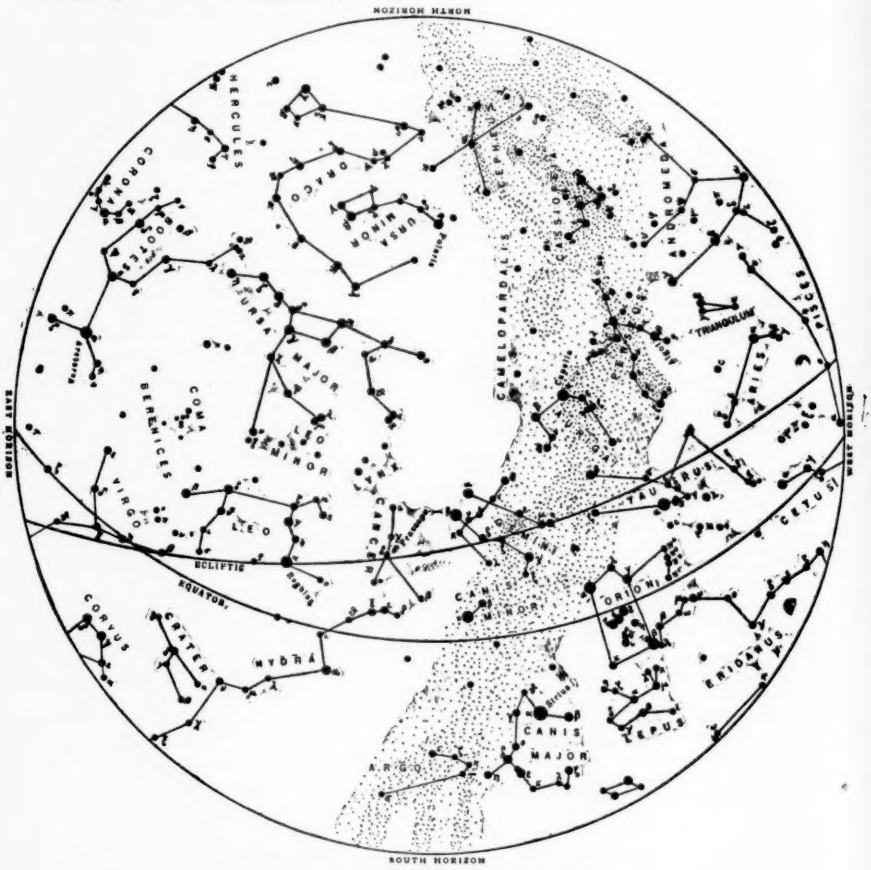
Mars will not be visible.

Jupiter may still be observed although its position is such as to make it less favorable for telescopic observation. It will be found near the western boundary of Pisces.

Saturn may be found in the constellation of Cancer. It will be well situated in the sky for observation, crossing the meridian in the early evening. Its stellar magnitude is decreasing. On the 14th of the month its magnitude will be +0.2.

Uranus will be too near the sun to be visible during the month.

Neptune may be seen with the aid of a small telescope in the constellation of Cancer. It is very faint and cannot be seen without the aid of a telescope. Its stellar magnitude is 7.7.



THE CONSTELLATIONS AT 9:00 P. M. MARCH 1.

Occultations Visible at Washington.

[*From the American Ephemeris*].

Date 1917	Star's Name	Magnitude	IMMERSION. Washington M.T.	IMMERSION. Angle f'm N.	EMERSION. Washington M.T.	EMERSION. Angle f'm N.	Duration
			h m	°	h m	°	h m
Mar. 6	83 B. Leonis	5.9	10 20	80	11 20	354	1 0
6	89 B. Leonis	6.2	12 11	141	13 31	292	1 20
6	π Leonis	4.9	13 44	119	14 57	307	1 13
10	370 B. Virginis	6.0	9 32	111	10 41	315	1 9
12	9 G. Librae	6.5	10 16	103	11 18	309	1 2
25	μ Arietis	5.7	9 19	80	10 10	263	0 51
28	118 Tauri	5.4	8 13	54	9 3	327	0 50
31	10 H. Cancri	6.1	7 18	136	8 44	278	1 26

Saturn's Satellites for March, 1917.

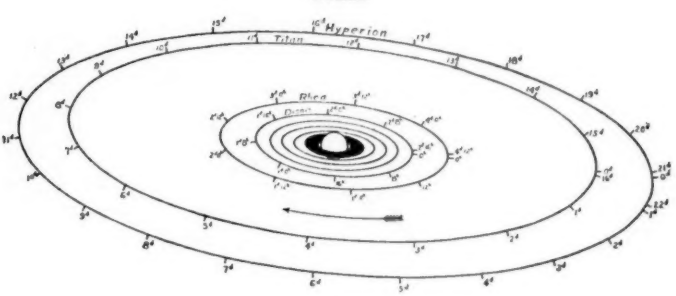
[*From the American Ephemeris.*]

CENTRAL STANDARD TIME.

E = eastern elongation; W = western elongation;
I = inferior conjunction; S = superior conjunction.

I. Mimas. Period $0^d\ 22^h.6$.

Mar. 1 10.4 W	Mar. 8 12.0 E	Mar. 15 13.7 W	Mar. 23 13.9 E
2 9.0 W	9 10.7 E	16 12.3 W	24 12.5 E
3 7.6 W	10 9.3 E	17 10.9 W	25 11.2 E
4 6.2 W	11 7.9 E	18 9.5 W	26 9.8 E
5 16.2 E	12 6.5 E	19 8.1 W	27 8.4 E
6 14.8 E	13 16.4 W	20 6.8 W	28 7.0 E
7 12.4 E	14 15.0 W	22 15.3 E	30 15.5 W
			31 14.2 W



Apparent orbits of the Seven Inner Satellites of Saturn, at date of opposition, January 17, 1917, as seen in an inverting telescope

II. Enceladus. Period $1^d\ 8^h.9$.

Mar. 1 23.8 E	Mar. 10 5.1 E	Mar. 18 10.4 E	Mar. 26 15.7 E
3 8.7 E	11 13.9 E	19 19.2 E	28 0.6 E
4 17.5 E	12 22.8 E	21 4.1 E	29 9.5 E
6 2.4 E	14 7.7 E	22 13.0 E	30 18.4 E
7 11.3 E	15 16.6 E	23 21.9 E	
8 20.2 E	17 1.5 E	25 6.8 E	

III. Tethys. Period $1^d\ 21^h.3$.

Mar. 2 7.5 E	Mar. 9 20.7 E	Mar. 17 10.0 E	Mar. 24 23.2 E
4 4.8 E	11 18.0 E	19 7.3 E	26 22.5 E
6 2.2 E	13 15.3 E	21 4.6 E	28 17.8 E
7 23.4 E	15 12.7 E	23 1.9 E	30 15.1 E

IV. Dione. Period $2^d\ 17^h.7$.

Mar. 2 4.6 E	Mar. 10 9.7 E	Mar. 18 14.7 E	Mar. 26 1.9 E
4 22.3 E	13 3.4 E	21 18.4 E	29 13.5 E
7 16.0 E	15 21.0 E	24 2.1 E	

V. Rhea. Period $4^d\ 12^h.5$.

Mar. 3 10.1 E	Mar. 12 10.9 E	Mar. 21 11.7 E	Mar. 30 12.6 E
7 22.5 E	16 21.3 E	26 0.1 E	

VI. Titan. Period $15^d\ 23^h.3$.

Mar. 3 8.1 W	Mar. 11 14.1 E	Mar. 19 6.4 W	Mar. 27 12.6 E

Saturn's Satellites for March, 1917—Continued.

VII. Hyperion. Period $21^d\ 7^h.6$.

Mar. 9 12.4 E Mar. 21 2.7 W Mar. 30 16.3 E

VIII. Iapetus. Period $79^d\ 22^h.1$.

Mar. 8 18.5 S Mar. 29 12.9 E

IX. Phoebe. Period $523^d\ 15^h.6$.

	α Ph. − α Sat.	δ Ph. − δ Sat.		α Ph. − α Sat.	δ Ph. − δ Sat.
	m s	′ ″		m s	′ ″
Mar. 1	+2 24.1	−3 48	Mar. 17	+2 14.6	−2 56
3	23.2	3 42	19	13.0	2 50
5	22.2	3 35	21	11.4	2 44
7	21.1	3 28	23	9.8	2 37
9	20.0	3 22	25	8.0	2 31
11	18.7	3 16	27	6.2	2 25
13	17.4	3 9	29	4.4	2 19
15	+2 16.0	−3 3	31	+2 2.5	−2 12

Phenomena of Jupiter's Satellites.

[Visible at Washington.]

CENTRAL STANDARD TIME.

1917	h m				h m		
Mar. 4	5 55	II	Tr. I.	Mar. 13	6 24	II	Ec. R.
	8 0	II	Sh. I.	14	7 14	I	Tr. I.
	8 31	II	Tr. E.	15	7 38	I	Ec. R.
6	8 3	I	Oc. D.	22	6 36	I	Oc. D.
7	6 13	I	Sh. I.	23	5 57	I	Tr. E.
	6 46	III	Tr. E.		6 43	I	Sh. E.
	7 24	I	Tr. E.	25	6 56	III	Ec. D.
	8 22	I	Sh. E.	29	6 19	II	Tr. E.
8	5 42	I	Ec. R.	30	6 29	I	Sh. I.

Note:—I., denotes ingress; E., egress; D., disappearance; R., reappearance; Ec., eclipse; Oc., occultation; Tr., transit of the satellite; Sh., transit of the shadow.

VARIABLE STARS.

Two New Variable Stars,—The two variables designated as H. V. 3398 and 3399 are announced in the Harvard College Observatory Circular 194 by Miss Margaret Harwood. These were detected upon plates taken at the Harvard Observatory. One of these is the double star 7729 of Burnlam's Catalogue. A study of plates taken with an instrument which shows the stars as separate images, finds the variation to be due to the southern one of the two. Its range is from 9.8 to 10.7. Its period is given as 3.501 days. The other is a star whose position for 1900 is R. A. $2^h\ 26^m\ 19^s$, Dec. $+35°\ 7'.8$. It is a faint star ranging from 11.9 to 12.9 in magnitude. It is probably also of short period, possibly seven days or less.

Minima of Variable Stars of Short Period.

[Calculated by Lois N. Wilson at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard 6^h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1917 March							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8								
RT Sculptor.	31.5	−26 13	9.6—10.5	0 12.3	6 21;	14 13;	22 5;	29 21				
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	3 9;	10 19;	18 6;	25 16				
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	1 13;	9 1;	24 0;	31 11				
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	3 6;	9 9;	21 14;	27 17				
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	2 12;	9 15;	23 22;	31 2				
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	3 14;	10 11;	24 5;	31 1				
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	6 23;	14 3;	21 8;	28 12				
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	3 12;	12 7;	21 1;	29 20				
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	4 5;	12 4;	20 3;	28 1				
RX Cassiop.	2 58.8	+67 11	8.6— 9.1	32 07.6	4 1;							
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	1 11;	12 22;	18 16;	30 3				
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	6 5;	13 0;	19 19;	26 14				
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	5 9;	13 6;	21 4;	29 2				
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	8 9;	16 17;	25 0					
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	1 20;	9 17;	17 15;	25 12				
RW Persei	13.3	+42 04	8.8—11.0	15 04.8		10 19;	23 14					
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	8 9;	17 19;	27 6					
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1		13 4;	25 14					
TT Aurigae	5 02.8	+39 27	7.8— 8.7	0 16.0	3 13;	10 5;	23 13;	30 5				
RY Aurigae	11.5	+38 13	10.7—11.7	2 17.5	1 1;	9 6;	17 10;	25 15				
RZ Aurigae	42.9	+31 40	10.6—13.3	3 00.3	3 21;	9 21;	21 22;	26 23				
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	4 7;	12 23;	21 15;	30 7				
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9	5 13;	15 23;	26 8					
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	3 1;	11 2;	19 2;	26 3				
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	3 9;	9 3;	20 14;	26 9				
U Columbae	6 11.2	−33 03	9.2—10.0	2 19.2	2 5;	7 19;	19 0;	24 15				
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	4 4;	12 9;	20 13;	28 18				
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	6 13;	14 5;	21 19;	29 11				
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	2 16;	14 21;	27 2					
RU Monoc.	6 49.4	− 7 28	9.8—10.5	0 21.5	5 6;	12 10;	19 14;	26 18				
R Can. Maj.	7 14.9	−16 12	5.8— 6.4	1 03.3	4 7;	11 2;	17 22;	31 13				
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2		10 10;	19 17;	29 0				
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	3 3;	9 18;	22 23;	29 14				
TX Gemin.	30.3	+17 8	10.0—11.9	2 19.2	5 5;	13 15;	20 0;	30 10				
RR Puppis	43.5	−41 08	9.4—10.7	6 10.3	3 6;	9 16;	22 13;	28 23				
V Puppis	7 55.4	−48 58	4.1— 4.8	1 10.9	2 0;	9 7;	23 20	31 2				
X Carinae	8 29.1	−58 53	7.9— 8.7	0 13.0	9 17;	17 20;	25 23					
S Cancri	8 38.2	+19 24	8.2—10	9 11.6	9 15;	19 3;	28 14					
RX Hydrae	9 00.8	− 7 52	9.1—10.5	2 6.8	3 5;	10 1;	23 18;	30 14				
S Velorum	29.4	−44 46	7.8— 9.3	5 22.4	4 23;	10 21;	22 18;	28 16				
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	4 0;	10 18;	24 6;	30 0				
RR Velorum	10 17.8	−41 36	10.0—10.9	1 20.5	4 21;	12 7;	19 18;	27 4				
SS Carinae	10 54.2	−61 23	12.2—12.8	3 07.2	2 3;	8 18;	21 23;	28 13				
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	3 10;	12 5;	21 0;	29 19				
RW Urs. Maj.	35.4	+52 34	10.3—11.4	7 07.9	7 19;	15 3;	22 11;	29 19				
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	5 12;	12 7;	19 2;	25 21				
RZ Centauri	12 55.6	−64 05	8.5— 8.9	1 21.0	1 11;	8 23;	23 23;	31 11				
RS Can. Ven.	13 06.3	+36 28	7.5—12.5	4 19.2	7 8;	16 22;	26 13					
SS Centauri	13 07.2	−63 37	8.8—10.4	2 11.5	5 8;	12 19;	20 5;	27 16				
δ Librae	14 55.6	− 8 07	4.8— 6.2	2 07.9	7 8;	14 7;	21 7;	28 7				

Minima of Variable Stars of Short Period—Continued.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1917 March
	h m	° ′		d h	d h d h d h d h d h
U Coronae	15 14.1	+32 01	7.6— 8.7	3 10.9	3 2; 10 0; 23 19; 30 17
TW Draconis	32.4	+64 14	7.3— 8.9	2 19.4	9 16; 18 2; 26 12
SS Librae	15 43.4	−15 14	9.3—11.5	0 18.4	4 20; 12 12; 20 3; 27 19
SW Ophiuchi	16 11.1	− 6 44	9.2—10.0	2 10.7	1 14; 8 22; 23 15; 30 23
SX Ophiuchi	12.6	− 6 25	10.5—11.2	2 01.5	4 2; 12 8; 20 14; 28 20
R Arae	31.1	−56 48	6.8— 7.9	4 10.2	3 6; 12 2; 20 23; 29 19
TT Herculis	16 49.9	+17 00	8.9— 9.3	20 18.1	10 15; 19 22; 30 23
TU Herculis	17 09.8	+30 50	9.5—12	2 06.4	3 6; 10 2; 23 16; 30 11
U Ophiuchi	11.5	+ 1 19	6.0— 6.7	0 20.1	2 20; 11 5; 19 14; 27 0
u Herculis	13.6	+33 12	4.6— 5.4	2 01.2	2 16; 8 20; 21 3; 27 7
TX Herculis	15.4	+42 00	8.3— 9.0	1 00.7	8 0; 15 5; 22 10; 29 15
RV Ophiuchi	29.8	+ 7 19	9. —12	3 16.5	3 1; 10 10; 17 19; 24 4
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6	5 2; 13 5; 21 11; 29 15
TX Scorpii	48.6	−34 13	7.5— 8.2	0 22.6	3 10; 10 23; 18 12; 26 1
UX Herculis	49.7	+16 57	8.8—10.5	1 13.2	7 5; 14 22; 22 16; 30 10
Z Herculis	53.6	+15 09	7.1— 7.9	3 23.8	3 11; 11 11; 19 11; 27 10
WX Sagittae	53.6	−17 24	9.2—10.8	2 03.1	5 12; 14 0; 22 12; 31 1
WY Sagittae	17 54.9	−23 1	9.5—10.6	4 16.0	4 17; 14 1; 23 9
SX Draconis	18 03.0	+ 58 23	9.3—10.5	5 04.1	10 0; 21 8; 31 16
RS Sagittarii	11.0	−34 08	5.9— 6.3	2 10.0	1 10; 8 16; 23 4; 30 10
V Serpentis	11.1	−15 34	9.5—11.1	3 10.9	7 14; 14 11; 21 9; 28 7
RZ Scuti	21.1	− 9 15	7.4— 8.3	15 03.2	15 22 31 1
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	5 2; 12 6; 19 10; 26 13
RX Herculis	26.0	+12 32	7.0— 7.6	0 21.3	5 3; 12 5; 19 8; 26 11
SX Sagittarii	39.7	−30 36	8.7— 9.8	2 01.8	8 9; 16 17; 25 0
RR Draconis	40.8	+62 34	9.3—13	2 19.9	2 7; 10 19; 19 6; 27 18
RS Scuti	43.7	−10 21	9.3—10.3	0 15.9	2 12; 9 3; 22 10; 29 1
β Lyrae	46.4	+33 15	3.4— 4.1	12 21.8	7 19; 20 17
U Scuti	18 48.9	−12 44	9.1— 9.6	0 22.9	5 15; 13 6; 20 22; 28 13
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.4	4 13; 12 3; 19 17; 26 6
RV Lyrae	12.5	+32 15	11. —12.8	3 14.4	6 6; 13 1; 20 15; 27 20
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	7 19; 16 18; 25 17
U Sagittae	14.4	+19 26	6.5— 9.0	3 09.1	7 8; 14 2; 20 20; 27 14
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	4 15; 12 0; 19 9; 25 17
TT Lyrae	24.3	+41 30	9.3—11.6	5 05.8	2 11; 12 23; 23 11; 28 17
UZ Draconis	26.1	+68 44	9.0— 9.8	1 15.1	3 10; 9 23; 24 0; 29 12
SY Cygni	19 42.7	+32 28	10 —12	6 00.2	5 19; 11 19; 17 20; 29 20
WW Cygni	20 00.6	+41 18	9.3—13.4	3 07.6	3 0; 9 16; 22 22; 29 13
SW Cygni	03.8	+46 01	9. —11.7	4 13.8	6 8; 15 11; 24 15
VW Cygni	11.4	+34 12	9.8—11.8	8 10.3	9 5; 17 16; 26 2
RW Capric.	12.2	−17 59	8.8—10.6	3 09.4	4 5; 10 0; 24 13; 31 8
UW Cygni	19.6	+42 55	10.5—10.8	3 10.8	3 8; 10 5; 24 0; 30 22
V Vulpec.	32.3	+26 15	8.2—9.8	37 19.0	
W Delphini	33.1	+17 56	9.4—12.1	4 19.4	5 6; 14 21; 24 11
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	9 3; 18 8; 27 12
Y Cygni	48.1	+34 17	7.1— 7.9	1 12.0	3 4; 10 16; 18 4; 25 15
WZ Cygni	49.3	+38 27	9.9—10.8	0 14.0	4 0; 11 5; 19 5; 26 19
RR Vulpec.	20 50.5	+27 32	9.6—11.0	5 01.2	9 9; 15 12; 29 15
VV Cygni	21 02.3	+45 23	12.1—13.8	1 11.4	7 13; 14 22; 22 8; 29 17
AE Cygni	09.0	+30 20	10.8—11.4	0 23.3	8 16; 18 9; 28 1
RY Aquarii	14.8	−11 14	8.8—10.4	1 23.2	2 12; 10 9; 18 5; 26 2
RT Lacertae	21 57.4	+43 24	9.1—10.5	5 01.7	3 5; 13 9; 23 12
UZ Cygni	55.2	+43 52	8.9—11.6	31 07.3	27 20
RW Lacertae	22 40.6	+49 08	10.2—11.2	5 04.4	3 7; 13 16; 24 1; 29 5
TT Androm.	23 08.7	+45 36	11.3—12.6	2 18.3	8 19; 17 2; 25 10
Y Piscium	29.3	+ 7 22	9.0—12.0	3 18.4	1 0; 8 13; 23 14; 31 3
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	4 2; 12 8; 20 14; 28 20

Maxima of Variable Stars of Short Period.

[Calculated by Julia M. Hawkes at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5h; Central standard time 6h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1917. March							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SX Cassiop.	0 05.5	+54 20	8.6— 9.2	36 13.7					24 20			
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 1.7	1 15;	9 18;	17 22;	26 1				
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	6 2;	13 20;	21 13;	29 6				
RW Cassiop.	1 30.7	+57 15	8.9—11.0	14 19.2	7 7		22 3					
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	2 5;	10 4;	18 22;	26 1				
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	2 13;	10 8;	18 3;	25 23				
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	7 16;	14 23;	22 5;	29 12				
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0	9		25					
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	6 18;	15 8;	23 22					
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	3 20;	14 23	26 2					
RX Aurigae	4 54.5	+39 49	7.2— 8.1	11 15.0	3 21;	15 12;	27 3					
SX Aurigae	5 04.6	+42 02	8.0— 8.7	1 12.8	3 22;	11 13;	19 5;	26 21				
SY Aurigae	05.5	+42 41	8.4— 9.5	10 03.3	2 3;	12 6;	22 9					
Y Aurigae	21.5	+42 21	8.6— 9.6	3 20.6	6 1;	13 18;	21 11;	29 5				
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	5 16;	11 5;	16 18;	22 6				
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	5 16;	13 6;	20 19;	28 9				
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3		14 22						
RT Aurigae	23.0	+30 33	5.1— 6.0	3 17.5	1 6;	8 17;	23 15;	31 1				
RZ Camelop.	23.7	+67 06	11.0—13.0	0 11.5	2 19;	9 23;	24 9;	31 14				
W Gemin.	29.2	+15 24	6.7— 7.5	7 22.0	5 4;	13 2;	21 0;	28 22				
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	3 23;	14 3;	24 6					
RU Camelop.	7 10.9	+69 51	8.5— 9.8	12 06.5	6 13		28 20					
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5	8 17;	16 16;	24 15					
V Carinae	8 26.7	−59 47	7.4— 8.1	6 16.7	5 9;	12 2;	18 19;	25 11				
T Velorum	8 34.4	−47 01	7.6— 8.5	4 15.3	7 0;	16 7;	25 13					
V Velorum	9 19.2	−55 32	7.5— 8.2	4 08.9	1 12;	10 6;	18 23;	27 18				
RR Leonis	10 02.1	+24 29	9.1—10.1	0 10.9	3 11;	10 6;	23 19;	30 14				
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	7 8;	13 22;	20 13;	27 4				
S Muscae	12 07.4	−69 36	6.4— 7.3	9 15.8	8 14;	17 6;	26 22					
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	4 16;	12 16;	20 15;	28 14				
T Crucis	15.9	−61 44	6.8— 7.6	6 17.6	1 6;	8 0;	21 11;	28 5				
R Crucis	18.1	−61 04	6.8— 7.9	5 19.8	1 2;	12 18;	24 10;	30 5				
S Crucis	12 48.4	−57 53	6.5— 7.6	4 16.6	4 15;	9 7;	18 16;	28 2				
W Virginis	13 20.9	− 2 52	8.7—10.4	17 06.5	3 23;		21 6					
SS Hydrae	25.0	−23 08	7.4— 8.1	8 4.8	2 5;	10 10;	18 15;	26 19				
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	6 15;	13 6;	20 16;	27 17				
ST Virginis	14 22.5	− 0 27	10.3—11.4	0 09.9	8 5;	16 11;	24 16					
V Centauri	25.4	−56 27	6.4— 7.8	5 11.9	6 3;	11 14;	22 14;	28 2				
RS Bootis	29.3	+32 11	8.9—10.0	0 09.1	3 19;	11 9;	18 22;	26 11				
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	2 14;	10 1;	17 10;	24 20				
R Triang. Austr.	15 10.8	−66 08	6.7— 7.4	3 09.3	3 21;	10 16;	17 11;	24 5				
S Triang. Austr.	15 52.2	−63 29	6.4— 7.4	6 07.8	1 14;	7 22;	20 14;	26 22				
S Normae	16 10.6	−57 39	6.6— 7.6	9 18.1	2 13;	12 7;	22 2,	31 20				
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	8 6;	17 3;	26 0					
RV Scorpii	16 51.8	−33 27	6.7— 7.4	6 01.5	6 8;	12 10;	24 13;	30 14				
X Sagittarii	17 41.3	−27 48	4.4— 5.0	7 00.3	7 12;	14 12;	21 13;	28 13				
Y Ophiuchi	47.3	− 6 07	6.1— 6.5	17 02.9	7 2;		24 5					
W Sagittarii	17 58.6	−29 35	4.3— 5.1	7 14.3	1 3;	8 18;	16 8;	31 12				
Y Sagittarii	18 15.5	−18 54	5.4— 6.2	5 18.6	6 16;	12 11;	23 23;	29 18				
U Sagittarii	26.0	−19 12	6.5— 7.3	6 17.9	7 8;	14 2;	20 20;	27 14				
Y Scuti	32.6	− 8 27	8.7— 9.2	10 08.3	6 4;	16 12;	26 21					
Y Lyrae	34.2	+43 52	11.3—12.3	0 12.1	3 21;	9 22;	21 23;	28 0				
RZ Lyrae	39.9	+32 42	9.9—11.2	0 12.3	2 21;	9 0;	21 7;	27 10				
RT Scuti	44.1	−10 30	9.1— 9.7	0 11.9	3 18;	9 17;	21 14;	27 13				
κ Pavonis	18 46.6	−67 22	3.8— 5.2	9 02.2	5 11;	14 13;	23 15					
U Aquilae	19 24.0	− 7 15	6.2— 6.9	7 00.6	1 4;	8 4;	22 5;	29 6				

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1916. March
	h m	° ′		d h	d h d h d h d h
XZ Cygni	19 30.4	+56 10	8.6— 9.3	0 11.2	7 3; 14 3; 21 3; 28 3
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	6 12; 14 12; 22 12; 30 11
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	6 3; 13 20; 21 12; 29 5
η Aquilae	47.4	+ 0 45	3.7— 4.5	7 04.2	5 3; 12 7; 19 12; 26 16
S Sagittae	51.5	+16 22	5.6— 6.4	8 09.2	7 20; 16 5; 24 14;
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	5 9; 11 17; 24 8 30 16
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3	12 6; 28 9
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	4 17; 9 4; 18 0; 26 22
WY Cygni	52.3	+30 03	9.6—10.4	0 13.5	1 22; 8 16; 22 2; 28 20
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	7 4; 13 22; 20 15; 27 8
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4	10 18; 25 11
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	2 20; 10 17; 18 13; 26 10
SW Aquarii	10.2	— 0 20	9.9—10.8	0 11.0	3 16; 10 13; 24 8; 31 5
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	5 4; 14 21; 24 14; 29 11
Y Lacertae	22 05.2	+50 33	9.1— 9.6	4 07.8	4 8; 13 0; 21 16; 30 7
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	3 14; 8 23; 19 17; 30 11
Z Lacertae	36.9	+56 18	8.2— 9.0	10 21.1	5 9; 16 6; 27 3
RR Lacertae	37.5	+55 55	8.5— 9.2	6 10.1	2 9; 8 19; 21 15; 28 1
V Lacertae	22 44.5	+55 48	8.5— 9.5	4 23.6	3 7; 8 7; 18 6; 28 5
X Lacertae	45.0	+55 54	8.2— 8.6	5 10.7	3 8; 14 5; 25 2; 30 13
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	2 19; 8 6; 19 3; 30 0
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	5 7; 11 14; 17 21; 30 11
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4	13 1; 25 5
V Cephei	23 51.7	+82 38	6.0—7.0	0 23.6	2 17; 7 16; 17 16; 27 15

Maxima of Variable Stars of Long Period in 1917.—In the Harvard College Observatory Circular 197 are given the dates of 352 maxima of long period variables in 1917, predicted by Mr. Leon Campbell. Those for the months of February and March are:

Date	Desig.	Name
Feb. 2	093934	R Leo. Min.
2	162807	SS Herculis
5	052036	W Aurigae
5	144918	U Bootis
6	143227	R Bootis
6	164715	S Herculis
8	220714	RS Pegasi
10	011041	UZ Androm.
10	151731	S Cor. Bor.
10	*160021*	Z Scorpii
11	055353	Z Aurigae
12	122532	T Can. Ven
12	*162112*	V Ophiuchi
12	190529a	V Lyrae
14	*151520*	S Librae
14	154536	X Cor. Bor.
17	060450	X Aurigae
17	123160	T Urs. Maj.
17	*170215*	R Ophiuchi
18	194348	TU Cygni
20	*161607*	W Ophiuchi
20	210812	R Equulei
21	083350	X Urs. Maj.
21	*210124*	V Capricorni
21	214024	RR Pegasi
22	181103	RY Ophiuchi
23	021024	R Arietis
24	*120905*	T Virginis
25	065111	Y Monoc.
26	071713	V Gemin.
27	142584	R Camelop.

Date	Desig.	Name
Mar. 1	032043	Y Persei
1	*090024*	S Pyxidis
4	*191319*	S Sagittarii
6	022150	RR Persei
6	200715a	S Aquilae
7	*155018*	RR Librae
12	065355	R Lyncis
12	175111	RT Ophiuchi
13	*094023*	RR Hydrae
13	170627	RT Herculis
14	225914	RW Pegasi
16	181136	W Lyrae
16	194632	χ Cygni
18	184243	RW Lyrae
18	205017	X Delphini
19	175519	RY Herculis
20	204846	RZ Cygni
20	*210504*	RS Aquarii
22	030514	U Arietis
22	045307	R Orionis
22	185634	Z Lyrae
24	010102	Z Ceti
24	*162815*	T Ophiuchi
26	073723	S Gemin.
27	123307	R Virginis
27	200212	SY Aquilae
28	001046	X Androm.

COMET AND ASTEROID NOTES.

Ephemeris of the Asteroid Ocllo (475).—I am sending you ephemeris of asteroid Ocllo (475) which will be in opposition April 10, 1917. The eccentricity of the orbit is greater than that of any other known asteroid except Albert (719). The ephemeris is based upon elements in Berlin Jahrbuch 1917.

Greenwich Midnight 1917	α h m s	δ ° ′ ″	log *r*	log Δ
Feb. 14	13 49 17	−0 21 10	0.51626	0.42794
" 18	13 48 51	−0 18 12	0.51504	0.41811
" 22	13 48 3	−0 13 39	0.51376	0.40837
" 26	13 46 53	−0 7 44	0.51250	0.39895
Mar. 2	13 45 41	−0 5 5	0.51120	0.38995
" 6	13 43 27	+0 7 28	0.50988	0.38101
" 10	13 41 11	+0 16 40	0.50856	0.37274
" 14	13 38 35	+0 26 41	0.50718	0.36494
" 18	13 34 39	+0 37 15	0.50576	0.35775
" 22	13 32 25	+0 48 14	0.50436	0.35135

Opposition April 10, 1917

F. E. SEAGRAVE,

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers, December-January, 1916-1917.

We welcome as new members of the Association this month the following observers:—

Mr. F. E. Brasch, "Bh" Cambridge, Mass.
Mr. Charles A. Bruun, "Bn" Kansas City, Mo.
Mr. Paul F. Johnson, "Jo" Altadena, Cal.
Dr. C. J. Larsen, "La" Negaunee, Mich.
Mr. W. J. Luyten, "Lt" Deventer, Holland.
Mr. O. F. Munson, "Mn" Brooklyn, N. Y.
Miss Alice E. Taylor, "T" Geneva, N. Y.

Mr. Luyten of Deventer, Holland, contributed a fine set of observations to this report, and we are glad of the good spirit of co-operation shown by observers in other lands.

The Association is indebted to Mr. Lindsley of Cincinnati, O., for publishing light curves of many of the variables from the data in the Reports. Mr. Lindsley recently sent the secretary a set of blue prints of sixty curves, neatly bound, which are a valuable addition to our records.

A maximum of the Variable 060547 SS Aurigae was observed by Mr. Burbeck December 16th. Mr. Burbeck communicated the fact to the Harvard College Observatory and it was made the subject of a special Bulletin.

A well-observed maximum of the Variable 213843 SS Cygni took place about December 24th. This proved to be a short maximum, the third successive maximum of this type,—an unprecedented occurrence in the history of this remarkable star.

VARIABLE STAR OBSERVATIONS December-January, 1916-17.

Nov. 0 = J. D. 2421168; Dec. 0 = 2421198 ; Jan. 0 = 2421229

001032
S Sculptoris

J.D. 242	Est.	Obs.
1199.6	9.1	Bu
1223.5	6.8	Ba

001046
X Androm.

1199.6<12.0		Bu
1223.5	12.8	Ba

001620
T Ceti

1181.3	5.5	L
90.3	5.7	Lt
93.6	5.4	G
95.6	5.7	Lt
97.6	5.4	G
98.6	5.4	G
1208.6	5.5	G
11.7	5.5	G
15.5	5.7	G
17.6	5.8	G
20.6	5.8	G
23.6	5.7	G
25.7	5.6	G
26.7	5.7	

001726
T Androm.

1199.6<11.8		Bu
1223.5<13.0		Ba

001755
T Cassiop.

1199.6	12.1	Bu
1211.6	11.7	Nt
21.6	11.5	Pi
23.5	11.2	Ba

001838
R Androm.

1199.6	12.1	Bu
1211.6	11.7	Nt
17.6	11.5	Hu
21.6<10.6		Pi
23.5	12.5	Ba

001909
S Ceti

1159.4	8.3	Lt
65.4	8.4	Lt
67.3	8.5	Lt
68.4	8.5	Lt
77.2	8.6	Lt
81.3	8.7	Lt
82.4	8.7	Lt
85.3	8.8	Lt
87.4	8.8	Lt
88.4	8.9	Lt
90.3	9.2	Lt
95.3	9.7	Lt
99.6	9.8	Bu

S Ceti

J.D. 242	Est.	Obs.
1208.6	10.2	M
14.6<10.5		D
14.6<10.2		Pi
14.7	11.0	R
17.6	8.2	Hu
23.5	11.5	Ba
27.5	<9.3	S

003179
Y Cephei

1199.6	9.4	Bu
1217.6	10.5	Hu
23.5	10.5	Ba

003831
RX Cephei

1173.3	7.5	Lt
74.3	7.5	Lt
82.2	7.7	Lt
85.3	7.8	Lt
95.5	7.6	Lt

004047
U Cassiop.

1199.6<12.1		Bu
1221.6<12.2		Pi
23.5<12.6		Ba

004132
RW Androm.

1199.6	10.9	Bu
1211.6	11.5	Nt
21.6<11.5		Pi
23.5	12.4	Ba

004435
V Androm.

1199.6<12.0		Bu
1217.6<12.6		Hu
23.5<13.2		Ba

004533
RR Androm.

1199.6	11.9	Bu
1211.5	12.3	Nt
23.5	13.0	Ba

004746
RV Cassiop.

1199.6	9.1	Bu
1223.5<12.3		Ba

004958
W Cassiop

1199.6	11.3	Bu
1211.4	11.0	Y
11.5	11.2	Nt
17.6	11.4	Ba
21.6	11.5	Pi

010102
Z Ceti

J.D. 242	Est.	Obs.
1205.6<12.1		Bu
23.5	13.0	Ba

010940
U Androm.

1205.6	9.8	Bu
21.6	11.1	Pi
23.5	10.8	Ba

011208
S Piscium

1205.6<11.8		Bu
23.5	13.5	Ba

011272
S Cassiop.

1208.6	8.7	M
14.6	8.9	Bu
14.7	9.2	R
21.5	9.0	Pi
23.5	8.2	Ba

011712
U Piscium

1205.6<12.3		Bu
23.6	10.8	Ba

012350
RZ Persei

1205,6<11.8		Bu
23.6<13.1		Ba

012502
R Piscium

1171.3	7.7	Lt
78.3	7.7	Lt
82.3	7.7	Lt
84.5	7.7	Lt
85.3	7.7	Lt
90.3	7.8	Lt
95.4	7.8	Lt
1208.6	8.4	Bu
11.5	8.9	O
14.6	8.7	Pi
14.6	8.9	Bu
14.7	8.8	R
17.5	8.9	O
23.6	8.6	Ba
27.6	9.4	S

013238
RU Androm.

1205.6<12.1		Bu
23.6	10.5	Ba

013338
Y Androm.

1223.6	8.3	Ba

014958
X Cassiop.

J.D. 242	Est.	Obs.
1205.6<11.6		Bu
08.6<11.3		M
11.4	12.3	Y
21.6<11.6		Pi
23.6	13.0	Ba

015354
U Persei

1165.4	8.7	Lt
68.3	8.5	Lt
70.6	8.3	Lt
74.3	8.2	Lt
82.3	8.2	Lt
85.3	8.2	Lt
90.3	8.3	Lt
95.5	8.2	Lt
1208.6	8.4	Bu
14.5	8.0	Pi
15.6	7.4	Hu
15.6	8.5	V
15.6	8.8	Bu
23.6	8.2	Ba
26.6	8.4	V

015912
S Arietis

1205.6<12.0		Bu
23.6	10.8	Ba

021024
R Arietis

1185.3	10.6	Lt
1205.6	10.9	Bu
14.6<10.0		Pi
23.6<12.0		Ba

021143
W Androm.

1223.6	12.4	Ba

021281
Z Cephei

1215.6<11.0		V
26.6<11.5		V

021403
o Ceti

1170.6	3.9	Lt
71.3	4.0	Pe
73.3	3.9	Lt
74.3	3.8	Lt
77.5	3.8	Lt
78.3	3.8	Lt
80.3	3.8	L
80.4	3.8	Lt
81.3	3.7	L
81.3	3.9	Lt

o Ceti

J.D. 242	Est.	Obs.
1181.3	3.9	Pe
82.3	3.9	Pe
82.4	3.9	Lt
83.3	3.9	Pe
83.5	3.9	Lt
84.4	3.9	Lt
85.3	3.9	Lt
87.3	3.9	Lt
88.4	3.9	Lt
90.3	3.9	Lt
90.4	3.9	Pe
91.3	3.8	Pe
92.3	3.9	Pe
93.6	3.9	G
94.4	3.9	Lt
95.3	3.9	Lt
97.2	3.9	Pe
97.2	3.7	L
97.4	3.5	L
97.6	3.9	G
98.6	3.9	G
99	3.8	T
99.6	3.7	Bu
1205.6	3.7	Bu
08.5	3.8	O
08.6	4.0	G
08.6	3.6	Bu
09.6	3.6	Mu
09.7	3.9	R
10.7	3.6	Mu
10.7	4.0	G
11	3.9	T
11.5	3.9	O
11.6	4.1	G
11.7	3.7	Mu
12	4.3	T
12.5	3.9	O
12.6	3.7	Mu
12.6	3.7	R
12.6	3.8	Ba
14.6	3.6	R
14.6	3.7	Bu
14.6	4.0	Pi
14.7	4.0	G
15.5	4.0	O
15.5	4.0	Cr
15.6	4.1	G
15.6	4.2	M
15.6	4.0	Mu
15.6	3.9	Bu
17.5	3.8	Ba
17.5	4.2	O
17.6	4.2	G
17.6	3.9	Hu
18.6	4.0	Mu
20.6	4.2	G
20.8	4.0	Mu
21.6	4.2	Cr
21.7	4.4	Pi

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o Ceti

J.D. 242	Est.	Obs
1222.6	4.1	Mu
22.6	4.3	G
23.5	4.3	O
23.6	3.8	Ba
24.4	4.5	T
24.5	4.3	O
24.6	4.0	Cr
24.6	4.0	Bu
24.6	4.3	G
25.6	4.3	G
25.7	4.2	E
26.5	4.4	O
26.5	4.4	Nt
26.6	4.0	Ba
26.6	3.7	Bu
26.7	4.3	G
27.5	4.3	O
27.6	3.5	Bu

021558
S Persei

1208.6	8.8	Bu
14.5	9.5	Pi
23.6	9.0	Ba

022000
R Ceti

1205.6	7.6	Bu
11.5	7.8	Nt
23.6	8.3	Ba
24.5	8.4	O

022150
RR Persei

1211.5	11.3	Y
14.6	11.8	Pi
17.6	11.7	Ba

022813
U Ceti

1217.5	8.9	O
23.6	8.3	Ba
24.5	8.5	O

023080
RR Cephei

1215.6<11.0		V
26.6<11.5		V

023133
R Triang.

1170.6	8.0	Lt
81.3	7.9	Lt
84.4	7.7	Lt
85.3	7.7	Lt
90.3	7.5	Lt
93.6	7.6	G
95.5	7.2	Lt
99	7.7	T
1201	7.5	T
04.5	7.2	Me

R Triang.

J.D. 242	Est.	Obs.
1205	7.4	T
08	7.5	T
08.5	6.7	O
08.6	7.0	Bu
12.5	7.1	O
15	7.7	T
15.6	7.3	Mu
15.6	7.4	Bu
17.6	6.7	Pi
21.6	7.0	Hu
23.5	7.0	O
23.6	7.1	Ba

024217
T Arietis

1199	10.1	T

024356
W Persei

1208.6	9.0	M
08.6	9.2	Bu
11.7	9.0	Mu
14.6	9.0	Bu
14.6	9.5	Pi
15.6	9.2	Hu
15.6	9.1	Mu
22.5	9.0	Ba
26.8	9.6	M

030514
U Arietis

1205.6<11.9		Bu
23.6	13.2	Ba

031401
X Ceti

1170.6	9.2	Lt
82.3	9.1	Lt
85.3	9.0	Lt
90.3	9.1	Lt
95.3	9.2	Lt
1214.6	10.1	Bu
17.6	10.5	Hu
23.6	10.5	Ba
28.6	10.8	D

032043
Y Persei

1208.6	9.0	Bu
14.6	8.5	Pi
15.6	8.2	Hu
22.5	8.4	Ba
23.5	8.6	O
26.8	8.6	M

032335
R Persei

1208.6	8.4	Bu
11.5	9.2	Y
14.5	8.5	Pi
22.5	8.3	Ba
23.6	8.2	Hu
26.8	9.2	M
27.5	9.0	S

033362
U Camelop.

J.D. 242	Est.	Obs.
1205.6	7.8	Bu
22.5	7.5	Ba

035124
T Eridani

1214.6	10.0	Bu
26.6	11.5	Ba

035915
V Eridani

1214.6	10.0	Bu
15.5	9.5	Pi
26.6	9.3	Ba

042209
R Tauri

1208.6<10.6		Bu
26.6<13.0		Ba

042215
W Tauri

1197.3	9.9	Pe
1208.6	9.8	Bu
11.5	9.9	O
11.5	9.0	B
12.6	10.0	Wpi
14.6	8.4	Hu
14.6	10.1	Bu
17.5	9.6	O
17.6	9.2	Ba
21.7	9.9	Pi
22.6	9.0	Ba
23.5	9.6	O
23.6	9.4	M
26.6	9.4	Ba
27.7	10.0	Wh

042309
S Tauri

1208.6<10.6		Bu
26.6<13.0		Ba

043065
T Camelop.

1211.5<13.5		Y

043208
RX Tauri

1208.6	10.5	Bu
11.5	10.6	Y
12.5	11.2	O
17.6	10.2	Hu
21.7	11.0	Pi
23.5	11.2	Ba
23.5	11.0	B

043274
X Camelop.

1199.4	10.8	T
1205.4	10.2	T
08.3	9.2	T
08.5	9.0	O
08.6	10.1	Bu
11.5	8.9	O
11.5	8.7	Y

X Camelop;

J.D. 242	Est.	Obs.
1112.4	8.9	T
12.5	8.9	O
15.5	8.7	O
15.5	9.1	Cr
15.6	9.1	V
17.5	8.8	O
20.6	8.9	V
21.5	8.7	Pi
23.5	8.8	O
23.6	8.5	Ba
24.6	9.0	Cr
26.5	8.7	O
26.6	8.8	Cr
26.6	8.3	Ba
26.6	8.3	Ba
26.6	8.6	V
29.7	8.3	Pi

044617
V Tauri

1208.6	9.2	Bu
15.5	10.7	O
17.5	9.9	B
17.6	10.0	Ba
26.6	11.3	Ba
27.6	11.0	V
29.6	11.2	M
29.7	12.0	Pi

045307
R Orionis

1208.6<12.1		Bu
15.6<11.2		O

045514
R Leporis

1208.6	7.5	Bu
14.6	7.4	G
15.6	7.7	M
17.6	6.3	Ba
17.7	7.4	G
23.6	7.5	G
24.6	7.6	G
25.7	7.6	G
26.7	7.5	G
28.7	7.8	Pi

050001
W Orionis

1215.6	6.0	G
17.6	5.9	G
20.6	6.0	G
23.6	6.4	G
24.6	6.5	G
26.7	6.3	G
27.7	6.3	G

050003
V Orionis

1208.6	12.5	Bu
26.6	13.0	Ba

050022
T Leporis

J.D. 242	Est.	Obs.
1197.4	9.0	L
1214.6	9.5	Bu
15.6	8.6	M
17.6	8.3	Ba
28.7	8.7	Pi

050953
R Aurigae

1199	9.0	T
1208.6	11.1	Bu
17.6	11.5	Pi
20.8	10.6	M
26.6	11.9	Ba

052034
S Aurigae

1208.6	9.9	Bu
12.6	9.1	Wpi
17.5	9.1	B
17.6	9.3	Pi
20.8	9.0	M
21.6	9.2	Wh
26.6	8.2	Ba

052036
W Aurigae

1208.6<12.0		Bu
17.6	12.5	Ba
25.5	12.1	Ba
26.6	12.0	Ba

052405
S Orionis

1208.6	9.1	Bu
11.5	8.3	B
14.6	8.3	D
15.6	8.3	M
17.6	8.1	Ba
28.6	7.5	D
29.6	8.0	M

053068
S Camelop.

1208.5	9.0	O
08.6	9.8	Bu
17.6	8.8	Ba

053005
T Orionis

1208.6	9.8	Bu
11.5	9.4	B
11.6	9.7	Nt
15.5	9.9	Pi
15.6	10.1	M
17.6	9.9	Ba
27.6	9.7	Wh
29.6	10.4	M

053531
U Aurigae

1214.6	11.8	Bu
20.8	11.1	M

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054319
SU Tauri

J.D. 242	Est.	Obs.
1199.6	<12.6	Bu
99.6	<12.1	Cr
99.7	<12.1	Wh
1205.6	<12.6	Bu
08.6	<12.6	Bu
11.5	12.5	Y
11.6	<12.0	Nt
14.6	12.3	Bu
15.6	12.3	Bu
15.6	<11.5	O
15.6	<12.3	Cr
17.5	11.9	Wh
17.6	12.2	Cr
17.6	11.4	Ba
20.6	11.2	Wh
21.5	10.6	Ba
23.6	10.5	Ba
23.6	10.7	Wh
24.6	10.6	Cr
24.6	10.9	Bu
25.7	10.3	E
26.5	10.4	O
26.6	10.5	Cr
26.6	10.1	Ba
26.6	11.0	Bu
26.6	10.3	Pi
27.5	10.4	O
27.6	10.3	Wh
28.6	10.0	D
29.7	10.1	Wh
29.7	10.1	Pi

054920
U Orionis

J.D. 242	Est.	Obs.
1202.6	10.9	Ly
08.6	10.2	Bu
09.6	11.2	Ly
14.6	11.0	Hu
15.6	11.4	M
26.6	12.1	Cr
29.6	11.4±M	

054974
V Camelop.

J.D. 242	Est.	Obs.
1211.5	<13.0	Y
14.6	<12.2	Bu
15.6	<12.2	M
17.6	<12.8	Ba
20.9	<10.9	M
23.6	<13.0	Ba
26.6	<13.0	Ba

055353
Z Aurigae

J.D. 242	Est.	Obs.
1214.6	11.9	Bu
17.7	11.0	Pi
20.8	11.4	M

060124
S Leporis

J.D. 242	Est.	Obs.
1214.7	6.6	G
18.6	6.6	G
23.6	6.7	G
26.7	6.7	G

060450
X Aurigae

J.D. 242	Est.	Obs.
1212.6	8.7	Wpi
14.6	9.4	Bu
15.6	10.9	Wh
17.6	11.1	B
17.7	9.6	Pi
20.8	11.2	M
27.6	<11.6	V

060547
SS Aurigae

J.D. 242	Est.	Obs.
1193.7	<12.4	L
97.4	<12.0	L
99.6	<12.4	Cr
99.6	<11.8	Bu
99.7	<12.4	Wh
1203.7	<12.4	L
05.6	<11.2	Bu
08.6	<11.2	Bu
11.5	<13.0	Y
11.6	<11.2	Bu
12.5	<10.8	O
14.6	10.9	Bu
14.7	11.0	D
15.5	10.6	O
15.6	<10.9	Cr
15.6	11.2	Wh
15.6	11.3	Bu
17.5	<13.0	Ba
17.5	11.5	O
17.6	<12.0	Pi
17.6	<11.8	Wh
17.7	11.9	Cr
20.8	<11.4	M
21.5	<12.4	Cr
21.5	<13.0	Ba
21.6	<11.4	Wh
23.6	<13.3	Ba
24.5	<12.4	Cr
24.6	<12.6	Bu
26.6	11.2	Hu
26.6	<13.0	Ba
26.6	<11.8	Bu
27.7	<11.2	V
29.5	<12.4	Wh

061647
V Aurigae

J.D. 242	Est.	Obs.
1223.5	10.2	B

061702
V Monoc.

J.D. 242	Est.	Obs.
1217.7	7.0	Pi
23.6	7.5	Ba
26.8	8.2	M

063159
U Lyncis

J.D. 242	Est.	Obs.
1211.5	12.6	Y
12.5	<10.7	O
26.5	12.4	B
26.6	13.4	Ba

063508
S Lyncis

J.D. 242	Est.	Obs.
1212.5	11.2	O
15.5	11.0	O
26.6	11.9	Ba

064030
X Gemin.

J.D. 242	Est.	Obs.
1215.7	11.6	M

065111
Y Monoc.

J.D. 242	Est.	Obs.
1217.7	12.3	Pi
23.6	11.9	Ba

065208
X Monoc.

J.D. 242	Est.	Obs.
1217.7	9.5	Pi
23.6	8.3	Ba
26.9	8.5	M

065355
R Lyncis

J.D. 242	Est.	Obs.
1211.5	13.0±Y	

065820
TW Gemin.

J.D. 242	Est.	Obs.
1215.7	8.5	M
21.6	8.4	Wh
26.6	7.8	Ba
27.7	8.4	Pi

070122a
R Gemin.

J.D. 242	Est.	Obs.
1214.6	8.0	Hu
15.7	8.8	M
21.6	8.4	Wh
26.6	8.2	Ba
27.7	8.9	Pi

070122c
Z Gemin.

J.D. 242	Est.	Obs.
1215.7	12.3	M
21.6	<11.6	Wh
26.6	12.6	Ba

070310
R Can. Min.

J.D. 242	Est.	Obs.
1223.6	10.3	Ba
27.7	11.2	Pi

071713
V Gemin.

J.D. 242	Est.	Obs.
1227.7	<11.2	V

072708
S Can. Min.

J.D. 242	Est.	Obs.
1202.6	7.9	Ly
1203.8	8.0	M
12.6	7.9	O
14.7	7.8	D
15.6	8.0	O
15.7	7.9	M
23.6	8.3	O
23.6	7.7	Ba
26.6	8.5	O
26.9	7.8	M
27.6	8.3	S
27.7	8.3	Wh
27.7	8.3	Pi

072811
T Can. Min.

J.D. 242	Est.	Obs.
1215.7	11.6	M
23.6	12.1	Ba
27.7	12.1	Pi
28.7	11.9	D

073508
U Can. Min

J.D. 242	Est.	Obs.
1197.4	9.4	L
1203.7	9.3	L
15.6	9.8	O
15.7	9.3	M
23.6	9.3	Ba
26.5	9.8	O

073723
S Gemin

J.D. 242	Est.	Obs.
1221.6	<12.4	Cr
21.6	<11.5	Wh

074323
T Gemin.

J.D. 242	Est.	Obs.
1226.7	<11.5	Pi
26,9	<11.5	M

074922
U Gemin.

J.D. 242	Est.	Obs.
1193.7	<12.3	L
97.4	<10.9	L
99	<10.2	T
1203.7	<12.4	L
15	<10.2	T
15.6	<12.4	Cr
17.6	<12.4	Cr
17.6	<13.5	Ba
21.6	<12.6	Hu
21.6	<12.4	Cr
23.6	<13.3	Ba
24.6	<11.7	Bu
25.7	<12.4	E
26	<10.2	T
26.6	<12.4	Cr
26.6	<13.3	Ba
26.9	12.5?	M
27.7	<12.3	Pi

U Gemin.

J. D. 242	Est.	Obs.
1227.7	<11.7	V
27.7	<11.7	Wh
29.7	<12.3	Wh

081112
R Cancri

J.D. 242	Est.	Obs.
1217.6	9.9	Ba
28.7	10.2	Pi

081617
V Cancri

J.D. 242	Est.	Obs.
1217.6	8.1	Ba

081733
T Lyncis

J.D. 242	Est.	Obs.
1223.9	9.4	M

082405
RT Hydrae

J.D. 242	Est.	Obs.
1223.6	8.0	Ba
27.7	8.2	Pi

083019
U Cancri

J.D. 242	Est.	Obs.
1225.7	<11.6	E

084803
S Hydrae

J.D. 242	Est.	Obs.
1217.7	<11.0	Pi
23.6	<12.5	Ba

085908
T Hydrae

J.D. 242	Est.	Obs.
1223.6	11.0	Ba

085120
T Cancri

J.D. 242	Est.	Obs.
1203.7	9.4	L

090151
V Urs. Maj.

J.D. 242	Est.	Obs.
1197.4	10.2	L
1203.7	10.3	L

090425
W Cancri

J.D. 242	Est.	Obs.
1223.7	13.0	Ba

093014
X Hydrae

J.D. 242	Est.	Obs.
1227.7	8.9	Pi

093934
R Leo. Min.

J.D. 242	Est.	Obs.
1217.7	10.3	Ba
23.9	9.6	M
27.6	9.4	S
27.7	9.5	Pi

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094211
R Leonis

J.D. 242	Est.	Obs.
1170.6	7.1	Lt
83.5	7.1	Lt
89.7	7.5	Lt
91.6	8.0	Pe
95.6	7.7	Lt
1203.8	8.0	M
17.7	7.8	Ba
21.7	8.4	Pi
23.9	8.4	M
25.7	8.6	E
27.7	8.3	Wh
27.7	8.4	Pi

094622
Y Hydrae

1227.7	7.0	Pi

095421
V Leonis

1227.7	<11.8	Pi

103212
U Hydrae

1191.6	5.4	Pe

103769
R Urs. Maj.

1170.6	7.5	Lt
74.3	7.8	Lt
78.3	7.9	Lt
81.3	8.0	Lt
82.4	8.0	Lt
84.5	8.0	Lt
85.3	8.1	Lt
88.4	8.2	Lt
90.3	8.2	Lt
95.4	8.3	Lt
1202.6	8.2	Ly
03.8	8.6	M
08.7	8.9	Bu
08.6	8.5	Ly
20.8	9.7	M
21.6	9.4	Ba
27.6	10.2	S
27.8	9.8	Pi

122001
SS Virginis

1226.9	7.4	M

122532
T Can. Ven.

1220.9	9.9	M

123160
T Urs. Maj.

1197.2	11.0	Pe
02.6	11.5	Ly
08.6	10.5	Bu
20.8	8.8	M
23.6	8.4	Ba

T Urs. Maj.

J.D. 242	Est.	Obs.
1123.9	8.1	M
27.6	7.5	S
27.8	8.0	Pi

123307
R Virginis

1191.6	7.2	Pe
1203.7	8.2	L
23.9	10.1	M

123459
RS Urs. Maj.

1223.9	<10.6	M

123961
S Urs. Maj.

1202.6	10.5	Ly
1203.7	11.0	L
08.6	11.5	Bu
20.8	11.6	M
23.7	11.3	Ba
27.8	11.5	Pi

124606
U Virginis

1226.9	8.4	M

032706
S Virginis

1193.7	<9.0	L
1203.7	9.1	L
20.9	8.1	M
23.9	8.0	M

134440
R Can. Ven.

1206.1	7.8	M
20.9	8.2	M

141567
U Urs. Min.

1221.6	8.4	Ba
27.5	8.7	S
28.7	8.8	Pi

142539
V Bootis

1203.7	10.1	L
06.1	9.4	M

142584
R Camelop.

1211.5	10.8	Y
26.5	9.5	O

143227
R Bootis

1203.7	11.6	L
06.1	9.8	M
23.9	8.7	M
26.9	8.5	M

144918
U Bootis

J.D. 242	Est.	Obs.
1206.1	<10.2	M

151731
S Coronae

1223.9	10.0	M

153378
S Urs. Min.

1202.5	11.0	Ly
08.6	10.8	Ly
14.6	11.3	Bu
21.6	10.1	Ba
28.7	10.2	Pi

154428
R Cor. Bor.

1181.2	6.0	L
1203.7	6.0	L
23.9	6.0	M
26.9	6.0	M

154539
V Coronae

1223.9	8.6	M

155847
X Herculis

1181.3	6.0	L
97.2	6.0	L

162119
U Herculis

1202.5	11.1	Ly
08.5	11.4	Ly

162342
g Herculis

1171.3	5.3	Lt
72.3	5.2	Lt
74.3	5.1	Lt
77.2	5.1	Lt
78.3	5.1	Lt
81.3	5.1	Lt
85.3	5.1	Lt
88.3	5.2	Lt
90.2	5.2	Lt
95.2	5.2	Lt

163172
R Urs. Min.

1221.6	10.0	Ba

163137
W Herculis

1223.1	8.5	M

163266
R Draconis

1171.3	9.5	Lt
74.3	9.3	Lt
81.3	8.2	Lt
82.4	8.1	Lt

R Draconis

J.D. 242	Est.	Obs.
1183.5	8.1	Lt
84.5	8.1	Lt
85.3	8.0	Lt
88.4	7.9	Lt
90.3	7.9	Lt
95.4	8.0	Lt
99.6	8.0	Cr
99.6	8.1	Wh
1202.6	7.8	Ly
04.6	7.9	M
08.5	7.9	Cr
15.5	8.0	Cr
17.6	8.1	Cr
21.5	7.8	Ba
21.6	8.4	Cr
26.6	8.0	Cr
27.5	8.0	S

164055
S Draconis

1204.6	9.0	M

175458
T Draconis

1215.5	10.0	V
21.5	9.4	Ba

180531
T Herculis

1209.6	8.4	R

181136
W Lyrae

1204.6	<10.1	M
08.6	12.0	M

183308
X Ophiuchi

1180.2	8.0	L
85.3	8.1	Lt
95.2	8.3	Lt

184205
R Scuti

1170.2	5.0	Lt
71.2	5.0	Lt
72.3	4.9	Lt
73.3	5.0	Lt
74.3	5.2	Lt
77.2	5.3	Lt
78.3	5.2	Lt
80.2	5.0	L
81.2	5.2	L
81.3	5.4	Lt
82.2	5.4	Lt
85.3	5.6	Lt
89.2	5.8	Lt
90.2	5.9	Lt
93.6	5.2	G
95.2	6.0	Lt
97.2	5.6	L
97.6	5.3	G

R Scuti

J.D. 242	Est.	Obs.
1298.6	5.3	G
1204.2	5.8	L
08.5	6.0	Bu
08.5	6.2	G
09.6	6.2	R
11.5	6.2	G
15.6	6.0	Bu

185243
R Lyrae

1170.2	4.3	Lt
71.3	4.3	Lt
74.3	4.2	Lt
77.2	4.3	Lt
78.3	4.2	Lt
80.4	4.2	Lt
81.3	4.2	Lt
82.4	4.2	Lt
83.5	4.2	Lt
84.4	4.2	Lt
85.3	4.1	Lt
87.4	4.1	Lt
88.4	4.2	Lt
90.2	4.2	Lt
95.2	4.3	Lt

190108
R Aquilae

1180.3	8.9	L
97.2	10.0	L

190926
X Lyrae

1204.6	9.1	M
09.6	8.6	R

190967
U Draconis

1204.6	10.0	M
15.6	10.0	Hu

191637
U Lyrae

1204.6	9.5	M

192545
AF Cygni

1170.3	7.0	Lt
71.3	7.1	Lt
74.3	7.1	Lt
78.3	7.2	Lt
82.3	7.2	Lt
84.5	7.3	Lt
85.3	7.3	Lt
90.3	7.4	Lt
95.4	7.5	Lt

193449
R Cygni

1197.2	11.7	Pe
1204.6	11.4	M
15.5	11.5	Pi
15.6	10.5	Hu
17.6	11.6	Ba

VARIABLE STAR OBSERVATIONS December-January, 1916-17—Continued.

193732 TT Cygni

J.D. 242	Est.	Obs.
1197.3	8.0	L
1207.6	8.5	M
09.6	8.4	R
15.6	7.0	Hu
21.5	7.1	Ba

194029 SU Cygni

J.D. 242	Est.	Obs.
1198.6	6.3	G
1208.5	6.6	G
11.5	6.6	G
23.6	6.5	G

194048 RT Cygni

J.D. 242	Est.	Obs.
1170.3	7.4	Lt
71.3	7.4	Lt
73.3	7.4	Lt
74.3	7.4	Lt
78.3	7.4	Lt
82.3	7.4	Lt
84.4	7.4	Lt
85.3	7.4	Lt
90.3	7.5	Lt
95.4	7.7	Lt
1204.6	7.7	M
1205	7.8	T
08.5	8.3	O
09.6	8.6	R
12.5	8.4	O
15.5	8.4	Pi
15	8.0	T
15.6	8.0	Hu
17.4	8.5	Wh
17.5	8.4	O
17.6	8.3	Ba
23.5	8.5	O
24.5	9.4	S

194348 TU Cygni

J.D. 242	Est.	Obs.
1204.6	<11.2	M
15.6	11.0	Hu

194632 χ Cygni

J.D. 242	Est.	Obs.
1192.3	10.4	Pe
97.3	11.3	L
97.3	10.4	Pe
1204.6	10.5	M
09.6	10.4	R
14.6	10.8	R
15.5	10.6	O
15.5	10.2	Pi
17.6	10.2	Ba
21.6	10.2	Ba
28.4	11.2	Wh

195116 S Sagittae

J.D. 242	Est.	Obs.
1208.5	5.9	O
09.6	5.5	R
09.6	6.0	Mu
12.5	5.3	O
14.6	5.6	R
15.5	5.8	O

195849 Z Cygni

J.D. 242	Est.	Obs.
1204.6	<11.6	M
11.5	12.1	B
15.5	12.0	Pi
21.5	12.5	Ba
29.5	<11.6	Wh

200357 S Cygni

J.D. 242	Est.	Obs.
1204.6	9.7	M
09.6	9.0	R
17.5	10.1	Wh
21.5	10.0	Ba

200647 SV Cygni

J.D. 242	Est.	Obs.
1207.6	9.4	M
09.6	9.2	R
14.6	8.0	Hu
15.5	9.3	Pi
15.6	9.1	Mu
21.5	8.0	Ba

200747 RX Cygni

J.D. 242	Est.	Obs.
1215.6	7.8	Mu

200716a S Aquilae

J.D. 242	Est.	Obs.
1180.3	10.0	L
1208.6	9.4	M
09.6	10.3	R
21.5	10.8	Ba

200717b RW Aquilae

J.D. 242	Est.	Obs.
1208.6	8.8	M
09.6	9.0	R
14.6	8.9	R
21.5	9.2	Ba

200916 R Sagittae

J.D. 242	Est.	Obs.
1208.6	9.3	M
09.6	9.5	R
21.5	8.8	Ba

200938 RS Cygni

J.D. 242	Est.	Obs.
1171.3	9.0	Lt
74.3	9.0	Lt
84.5	9.0	Lt
85.3	9.0	Lt

RS Cygni

J.D. 242	Est.	Obs.
1190.3	9.0	Lt
95.4	8.9	Lt
97.3	8.5	L
1207.6	8.1	M
09.6	8.2	R
15.5	8.4	Pi
17.6	7.6	Ba
21.5	7.3	Ba
29.5	7.5	Wh

201008 R Delphini

J.D. 242	Est.	Obs.
1204.6	10.3	M
14.6	9.6	R
15.4	9.2	Wh
21.5	8.5	Ba

***201521* RT Capricorni**

J.D. 242	Est.	Obs.
1180.3	8.1	L
1203.2	8.1	L

201647 U Cygni

J.D. 242	Est.	Obs.
1180.3	9.2	L
97.3	8.8	L
1207.6	7.1	M
09.6	7.2	R
11.5	7.8	O
15.5	8.0	Cr
15.5	8.0	Pi
17.5	8.2	Cr
21.5	8.0	Cr
21.5	7.8	Ba
24.5	8.1	Cr
26.6	8.0	Cr
27.5	8.1	S
29.5	7.6	Wh

202539 RW Cygni

J.D. 242	Est.	Obs.
1197.3	8.8	L
1204.5	8.2	Me
04.6	8.4	M
09.6	9.6	R
21.5	8.2	Ba
29.5	8.4	Wh

202946 SZ Cygni

J.D. 242	Est.	Obs.
1197.3	9.9	L
1207.6	9.3	M
09.6	9.8	R
14.6	9.0	Hu
14.6	9.6	R
17.5	8.9	Ba
21.5	9.3	Ba
22.5	9.4	Ba
23.5	9.5	Ba
26.6	10.0	Ba

202954 ST Cygni

J.D. 242	Est.	Obs.
1214.6	12.4	Hu
15.5	<12.1	Pi
21.5	<12.6	Ba

203226 V Vulpeculae

J.D. 242	Est.	Obs.
1207.6	9.4	M
21.5	9.0	Ba

203611 Y Delphini

J.D. 242	Est.	Obs.
1221.5	10.2	Ba

203847 V Cygni

J.D. 242	Est.	Obs.
1204.6	9.1	M
15.5	9.5	Pi
21.5	8.3	Ba

203816 S Delphini

J.D. 242	Est.	Obs.
1211.5	9.6	Y
14.6	9.2	R

203817 U Delphini

J.D. 242	Est.	Obs.
1170.2	6.3	Lt
74.3	6.3	Lt
78.3	6.4	Lt
82.3	6.4	Lt
85.3	6.5	Lt
88.4	6.5	Lt
90.2	6.5	Lt
95.2	6.6	Lt

204016 T Delphini

J.D. 242	Est.	Obs.
1211.5	<13.0	Y
21.4	10.6	Wh

***204405* T Aquarii**

J.D. 242	Est.	Obs.
1214.6	10.4	R
15.6	9.9	Hu
21.5	10.5	Ba

205923 R Vulpeculae

J.D. 242	Est.	Obs.
1215.6	10.2	Hu
17.5	10.0	Wh
21.5	9.6	Ba
29.4	9.4	Wh
29.6	9.0	M

***210116* RS Capricorni**

J.D. 242	Est.	Obs.
1221.5	7.9	Ba

210868 T Cephei

J.D. 242	Est.	Obs.
1174.3	8·0	Lt
82.4	7.8	Lt
85.3	7.6	Lt
88.4	7.7	Lt
95.5	7.4	Lt
1209.7	6.5	R
11.5	6.5	O
17.5	5.7	Pi
23.6	5.5	Hu
24.5	6.4	O
26.7	5.7	G
27.5	5.7	S
27.7	5.5	G

211614 X Pegasi

J.D. 242	Est.	Obs.
1221.5	13.7	Ba

***211615* T Capricorni**

J.D. 242	Est.	Obs.
1221.5	9.6	Ba

213044 W Cygni

J.D. 242	Est.	Obs.
1170.2	5.8	Lt
71.3	5.8	Lt
73.3	5.8	Lt
74.3	5.8	Lt
78.3	5.9	Lt
80.4	5.9	Lt
81.3	5.9	Lt
82.4	5.9	Lt
83.5	5.9	Lt
84.4	5.9	Lt
85.3	6.0	Lt
87.5	6.0	Lt
88.4	6.1	Lt
90.3	6.0	Lt
93.6	6.5	G
95.4	6.1	Lt
97.3	5.9	L
97.6	6.5	G
1208.5	6.3	G
09.7	7.0	R
11.5	6.4	G
23.6	6.4	G
26.7	5.9	G

213678 S Cephei

J.D. 242	Est.	Obs.
1217.5	<11.0	Pi

213753 RU Cygni

J.D. 242	Est.	Obs.
1197.3	8.7	L
1207.6	8.3	M
21.5	8.2	Ba

213843 SS Cygni

J.D. 242	Est.	Obs.
1197.3	9.5	L
99.4	9.5	T
99.6	10.3	Bu

VARIABLE STAR OBSERVATIONS December-January, 1916-17—Continued

SS Cygni			SS Cygni			SS Cygni			222557 δ Cephei			231508 S Pegasi		
J.D. 242	Est.	Obs.	J.D. 242	Est.	Obs.	J.D. 242	Est.	Obs.	J.D. 242	Est.	Obs.	J.D. 242	Est.	Obs.
1200.3	10.8	T	15.7	<10.4	Mu	27.5	10.7	Wh	1220.6	4.0	G	1197.2	12.8	Pe
03.4	<10.9	Y	17.5	11.9	Pi	28.5	<9.6	S	23.6	4.0	G			
03.6	11.4	M	17.5	12.0	Cr	28.6	11.1	Pi	25.6	4.2	G	233335 ST Androm.		
04.5	11.3	Me	17.5	12.0	B	29.5	11.9	Pi	26.7	4.1	G	1214.6	11.6	Hu
04.6	11.5	M	17.5	11.6	Ba	29.5	11.6	Wh	27.7	4.1	G	14.7	11.1	R
05.3	<10.8	T	17.6	11.9	Hu	29.6	11.5	M	223841 R Lacertae			21.6	9.3	Ba
05.5	11.3	Y	20.5	9.1	V	213937 RV Cygni			1211.5	12.4	Y	21.6	10.5	Pi
05.6	11.8	Bu	21.5	8.6	Ba	1197.3	7.9	L	230110 R Pegasi			26.5	10.2	O
05.6	11.2	Me	21.5	8.7	Pi	1207.6	8.4	M				28.5	<9.3	S
07.6	12.0	M	21.5	9.1	Cr	14.6	7.5	Hu	1192.3	10.3	Pe	*233815* R Aquarii		
07.6	11.1	Me	21.5	8.7	Wh	14.6	7.8	R	97.2	10.2	Pe			
08.3	<10.8	T	21.6	9.0	Hu	21.6	6.9	Ba	1208.5	9.1	Me	1197.3	8.5	Pe
08.5	<10.9	D	21.6	9.1	V				08.5	9.3	O	97.4	8.2	L
08.5	<10.5	O	21.6	8.7	Bu	214058 μ Cephei			11.5	9.2	Nt	1214.7	9.0	R
08.5	11.2	Me	22.5	8.5	Ba				11.7	9.2	Mu	234982 V Cephei		
08.6	11.9	M	23.5	8.8	Ba	1220.6	3.5	G	12.5	9.0	O			
08.6	11.4	Bu	23.5	8.8	O	23.6	3.5	G	14.7	9.3	R	1173.3	6.6	Lt
09.6	<10.9	R	23.5	9.0	B	25.6	3.4	G	15.5	8.8	O	74.3	6.5	Lt
11.5	11.7	D	23.6	9.2	Hu	26.7	3.4	G	17.5	8.8	O	85.3	6.3	Lt
11.5	<10.0	O	23.6	9.0	M	27.7	3.4	G	21.6	8.7	Hu	95.6	6.4	Lt
11.5	11.7	Y	24.5	9.4	O				21.6	8.6	Ba	235350 R Cassiop.		
11.6	<10.9	Bu	24.5	9.5	Cr	214024 RRPegasi			21.6	8.6	Pi			
11.6	11.4	Nt	24.6	8.8	Bu				23.5	8.7	O	1214.7	9.3	R
11.7	11.2	Mu	26.5	10.0	O	1221.6	<11.4	Ba	29.6	8.7	M	21.6	12.2	Hu
12.4	<11.0	T	26.5	10.3	B	215934 RT Pegasi			230759 V Cassiop.			21.6	7.6	Ba
12.5	<10.5	O	26.5	10.2	V							235525 Z Pegasi		
12.6	<10.1	Wpi	26.5	9.8	D	1215.5	11.2	V	1217.5	9.6	O			
14.5	11.9	B	26.6	10.0	Hu	26.6	10.8	V	21.6	8.6	Ba	1211.5	8.7	O
14.6	11.7	Bu	26.6	10.3	Cr				21.6	9.4	Pi	15.6	8.8	V
14.6	11.9	Hu	26.6	10.2	Ba	222439 S Lacertae			23.5	9.5	O	23.5	8.7	O
14.6	<10.9	R	26.6	10.1	Bu				23.6	8.7	Hu	26.6	8.8	V
15.3	11.3	T	26.6	10.3	Pi	1211.5	9.6	Y	231425 W Pegasi			235939 SV Androm.		
15.5	11.9	Cr	27.5	10.4	O	14.7	9.3	R	1215.6	<11.0	V			
15.5	<11.3	V	27.5	<9.6	S	21.6	8.1	Ba	26.6	<11.0	V	1221.6	<12.6	Hu
15.5	11.9	Pi	27.5	10.0	D									

No. of observations 1140; No. of stars observed 199; No. of observers 25.

The irregular Variable 054319 SU Tauri, a variable of the R Coronae type, after waning last month has suddenly attained maximum, much to the surprise of all observers. The irregular variables are now being well observed and valuable data concerning them are being contributed.

Rev. T. C. H. Bouton is now located in St. Petersburg, Fla., and is observing variables in that favored locality.

There is an error on the blue print of the Variable 083019 U Cancri, retraced from Hagen's chart by E. W. P. There is no bright star immediately south of the 11.3 magnitude comparison star. The blue print of 144918 U Boötis from the same source is also defective and should be discarded. If members who have this chart will notify Mr. D. B. Pickering, new charts will be sent them.

Mr. McAteer deserves credit for his list contributed this month which contained many valuable early morning observations.

Mr. Mills of Jersey City, N. J., is now co-operating with others in the observation of certain phenomena of Jupiter's satellites.

The following calculated dates of maxima will be of interest to compare with the observed dates of maxima.

From the Companion to the Observatory	Dates of maxima predicted by Mr. Leon Campbell	
Feb. 3		*001620* T Ceti
5	Feb. 10	151731 S Coronae
7	Sept. 24	175458 T Draconis
12	Feb. 17	*170215* R Ophiuchi
15	May 5	231508 S Pegasi
16	Nov. 23	154639 V Coronae
19	Feb. 6	143227 R Boötis
25	Feb. 2	*022813* U Ceti.

At the recent meeting of the American Astronomical Society in New York City, Mr. D. B. Pickering ably represented our Association, and read a paper on the Variable 213843 SS Cygni contributed by Mr. Leon Campbell. A Committee was appointed to promote variable star observing. The object of this action was to express the interest of the Society in the work of our Association and to co-operate with it. The Secretary on behalf of the Association takes pleasure in thanking the American Astronomical Society for the compliment paid in this recognition of our activities, and greatly appreciates the wish expressed by the Society to co-operate in the work of the Association.

Dr. Gray is to be commended for his co-operation with us each month in spite of the fact that his position as Surgeon on a Pacific Liner keeps him at sea most of the time. During the past month the Doctor made seventy observations of variables that could be observed with a field glass, an admirable example of the valuable work that can be accomplished with simple optical equipment.

The reports from now until May first should be sent to the Secretary pro tem., Mr. John J. Crane, Shawme Farm, Sandwich, Mass. The report due May first should be sent to the undersigned on the first of the month.

The following members contributed to this report: Messrs. Bancroft, Bouton, Burbeck, Crane, Eaton, Gray, Hunter, Lacchini, Lindsley, Luyten, McAteer, Meeker, Mundt, Nolte, Olcott, de Perrot, D. B. Pickering, S. W. Pickering, Richter, Vrooman, Whitehorn, Yendell, Miss Swartz, and Miss Young.

WILLIAM TYLER OLCOTT,
Corresponding Secretary.

Norwich, Conn.
January 10, 1917.

COMMUNICATIONS.

Information Wanted.—One of our subscribers asks that someone, who has recently mounted a telescope for himself, will write an article explaining how to adapt a drive and clock control to a small equatorial telescope.

Studying Astronomy by One's Self.—One of the readers of POPULAR ASTRONOMY writes, "I do wish there was a school or class for amateurs who are interested in this branch of study. I have been studying and reading by myself for over two years and I make my own sky maps by drawing the constellations from the real objects. Once I had the rare treat of looking through a telescope. My opera glasses are the only instrument that I possess, and of course they are not very satisfactory. I am reading "Astronomy With An Opera-Glass", by Garrett

P. Serviss, and find it so interesting. There are lots of questions I'd like to ask, but I have no one to tell me, so I dig for myself. Some I find out, others have to wait."

This writer shows an admirable spirit. Very much of interest may be found in the heavens even with a small pair of opera-glasses. What one digs out for one's self is much more one's own than that which is obtained merely by reading the results of another's work.

POPULAR ASTRONOMY is always ready to publish sensible queries, and answers so far as they may be obtainable.

Zodiacal Light Reports.—In the interest of uniformity and in order to render reports of zodiacal light observations satisfactory and serviceable I venture to suggest the following scheme which students of this phenomenon may find helpful:

SCHEME FOR THE ZODIACAL LIGHT OBSERVATION REPORTS.

Date:				
Station:	Lat: Long:	Time of sunset (or sunrise):	Time of observation:	Inclination of Ecliptic to the horizon
Diagram:	Plotting of ecliptic, boundaries of light, principal stars in and adjoining illuminated area.			
Condition of weather:	Character of light: strong, diffuse, colored, etc. Comparison with galaxy. Note if the light can be traced clear across the sky.			Remarks describing any unusual appearance noted

W. E. GLANVILLE.

St Peter's Rectory,
Solomons, Md. 1916, Nov. 29.

GENERAL NOTES.

Mr. William Grunow, eighty-seven years old, who was for thirty-six years custodian of the United States Military Academy Observatory at West Point and a skilled instrument-maker, died on January 5.

Dr. Forest Ray Moulton, professor of astronomy in the University of Chicago, will give, in February, five lectures at Western Reserve University on the MacBride Foundation.

Mr. F. W. Levander, for many years editor of *The Journal of the British Astronomical Association*, died on December 20, at the age of seventy-seven years.

The death is announced of **Mr. William Ellis, F. R. S.,** in his eighty-ninth year. Mr. Ellis was formerly superintendent of the Magnetical and Meteorological Branch of the Royal Observatory, Greenwich. He joined the Observatory in 1841, and was attached to the astronomical department until 1874, having during the preceding eighteen years been in charge of the chronometric and electric branch.

Mr. H. C. Jenkins, maker of astronomical instruments and other optical apparatus, has recently moved his factory from 75 West 131st Street to 32 East 130th Street, New York. In the new factory which is larger, Mr. Jenkins will be better able to furnish instruments which may be ordered from him.

The Committee of One Hundred on scientific research of the American Association for the Advancement of Science held its fourth meeting at the Hotel Belmont, New York City, on the afternoon of December 26. Since last year thirteen subcommittees have been appointed to deal with various subjects. The subcommittee on astronomy consists of the following persons:

Edward C. Pickering, *Chairman*, E. W. Brown, E. B. Frost, H. N. Russell, F. Schlesinger.

Internal Motion in the Spiral Nebula Messier 101.—In a paper communicated to the National Academy of Sciences in June 1916, Dr. A. van Maanen gives the results of measurement of five photographs of the Spiral Nebula Messier 101, two taken by Mr. Ritchey at Mount Wilson in 1910 and 1915, and three taken with the Crossley Reflector on Mount Hamilton, one by Keeler in 1899, one by Perrine in 1908 and one by Curtis in 1914. The motions found are very minute but appear to indicate with considerable certainty that the knots of nebulosity which could be measured are moving outward in the direction of the arms of the spiral, that is, the spiral is unwinding instead of coiling up. The motion of rotation appears to be roughly three times as swift as the radial motion. At the rate indicated it would take the nebula about 85,000 years to complete one rotation.

Monomet, a New Photographic Developer.—The war has been the cause of stimulating activity in many commercial industries for the purpose of creating substitutes for products not now obtainable. One phase in which this comes rather close to the astronomer is the matter of suitable chemicals for the development of photographic plates. Since modern astronomy is carried on in so many lines by photographic processes, this becomes an important consideration. In *The British Journal of Photography* for January 5, a new developer is described which has been made by English chemists to take the place of metol, formerly obtained from Germany. This new developer is named "Monomet" and is said to be equal if not superior to developers formerly used.

Auxiliary Tables for Solving the Equation of Gauss:—The transcendental equation $\sin(z-q) = m \sin^4 z$, which Gauss derived in his method of determining the orbit of a planet from three observations, is difficult of solution by trial. The solution is very much facilitated by the *Tables Auxiliares* just published in Paris by Mr. Thadés Banachiewicz of the Astronomical Observatory of Jurieff (Dorpat), Russia.

The Smithsonian Astrophysical Observatory.—Director C. G. Abbot's annual report gives an account of various observations which support one another in confirming the variability of the sun, and some of which tend to indicate dual causes of it. An expedition is proposed to occupy the most favorable station in South America for several years, beginning in 1917, for the purpose of making, in connection with Mount Wilson observations, a full and accurate determination of the solar variation for comparison with climatic changes. A new instrument, called the pyranometer, for measuring skylight and nocturnal radiation has been tested and found accurate.

At Yerkes Observatory

Hours of Observation with 40-Inch Telescope

Month	1916	Mean for Decade	Gain 1916
October	198½	182½	16
November	169½	144½	25
December	167½	142½	25
Total for Quarter	535½	469½	66
Total for year	1973½	1681½	272

Rainfall at Yerkes Observatory.

Month	1916		Mean for Decade		Gain 1916	
	Inches	Millimeters	Inches	Millimeters	Inches	Millimeters
October	3.27	83	2.19	55	1.07	27
November	1.71	43	1.80	46	— .09	— 2
December	1.34	34	1.73	44	— .39	—10
Total for Quarter	6.31	160	5.72	145	0.59	15
Total for year	32.04	814	31.59	802	0.45	12

It thus appears from the above table that the year 1916 was decidedly more favorable for astronomical work at night than the average. It was, in fact, the best year of the fourteen since records have been kept at the Observatory in this particular way. With the exception of June, which had a deficit of ten hours, every month showed a gain in the nocturnal hours of observation over the 10-year average. The greatest gain was of course in the remarkably fine months of July and August. The year thus showed a gain of 292 hours, or 17 per cent more than the normal. The next best years in this respect were 1908, with 1883½ hours, and 1912, with 1866½ hours; the poorest years were 1906, with 1473½, and 1914 with 1480.

In addition to the greater number of clear hours at night, we enjoyed the advantage of better seeing: the number of nights, particularly during the summer with excellent seeing, was much larger than usual.

E. B. F.

Eclipses of Jupiter's Satellites.—In the Harvard College Observatory Circular 198, Professor Pickering urges amateur astronomers to observe the eclipses of Jupiter's satellites. There are unexplained deviations between the observed and computed times of these eclipses which need to be cleared up.

"After the opposition of Jupiter nearly all the eclipses are reappearances. It is only necessary to watch the position in which the satellite will appear and record the time in minutes and seconds with a good watch. Sometimes the satellite is

suspected and a few seconds later certainly seen. If possible, both times should be recorded. The disappearances are still more easily observed, but they generally occur after midnight, before Jupiter is in opposition."

It is essential that the error of the watch should be known. This can be obtained by comparison with the railroad telegraphic time signals, or with the wireless signals which are sent from Arlington, Va., for five minutes before nine o'clock p. m., Central Standard time.

The times of the eclipses are given to the nearest minute in POPULAR ASTRONOMY each month. These are taken from the *American Ephemeris*.

A Large Reflector for the Argentine National Observatory.— In the *Publications* of the Astronomical Society of the Pacific for December 1916, Director C. D. Perrine describes the site which has been selected for the new reflecting telescope of 1½ meter aperture which is soon to be completed for the Argentine National Observatory at Córdoba. The reflector will be located near the southern extremity of the Sierra Chica, about 40 kilometers southwest of Córdoba. The Sierra Chica is of the usual type of low mountain formation, resembling in general appearance the Coast Range to the west of Mount Hamilton, except that there is much less vegetation in the Sierra Chica. The site selected for the reflector is a rounded knob, 1200 meters above sea-level, on the west side of the range, overlooking the valley between the Chica and the Grande. From its summit are visible Alta Gracia, the nearest railway station, 20 kilometers distant to the southeast; Córdoba, 40 kilometers to the northeast, and the extensive pampas for a long distance to the north, east and south, as well as the higher mountains to the west and north.

The site is donated by Mr. Henry Reynolds and contains, besides the hill proper on which will be located the telescope, an extension to the canyon to the south, in which is a small stream of perpetual water. A study of meteorological conditions indicates that the nocturnal range of temperature is only about 2° C.

It is not planned to move the National Observatory to the new site, but to have most of the observatory work done at Córdoba.

Resumé of Sunspot Observations at Mt. Holyoke College, 1916.

Month	No. of Obs.	North of Equator No. Groups	North of Equator Av. Lat.	South of Equator No. Groups	South of Equator Av. Lat.	Av. No. at Each Obs.	New Groups
			°		°		
Jan.	14	11	+18.5	6	−16.5	2.93	17
Feb.	11	8	+18.6	7	−15.0	2.73	13
Mar.	16	9	+18.7	9	−18.5	3.56	16
Apr.	13	9	+14.7	9	−18.8	3.92	13
May	20	10	+15.7	13	−18.7	4.50	17
June	4	2	+10.5	3	−15.2	2.00	2
Sept.	1	0		0			
Oct.	22	12	+17.2	7	−21.1	3.95	19
Nov.	19	14	+18.7	8	−15.6	4.94	19
Dec.	12	9	+20.3	7	−16.3	4.50	14
Totals	132	84		69			130

Average numbers at each observation..... 3.89
Average latitude of groups north of equator.....+17°.8
Average latitude of groups north of equator .....−17°.9

The method of observation was the same as that followed in previous years. The observation made September 30 was the only one when no spots were seen.

LOUISE F. JENKINS,

John Payson Williston Observatory.

The Flower Astronomical Observatory.—Vol. I, Part I, of the Astronomical Series of Publications of the University of Pennsylvania contains a history and description of the Flower Astronomical Observatory, with a determination of its longitude. Excellent reproductions of photographs of the buildings and instruments accompany the descriptive matter.

"The Flower Astronomical Observatory is situated on the Westchester Pike, one mile west of the Sixty-ninth Street Terminal of the Philadelphia Elevated Road. Its existence is due to the liberality of Reese Wall Flower, a citizen of Deleware County, Pennsylvania, who bequeathed the greater part of his estate, approximately one hundred thousand dollars in value, to the University of Pennsylvania for the purpose of founding and maintaining an observatory."

The observatory was formally opened on May 12, 1897, but active astronomical work had been begun in the preceding October. The principal buildings are the equatorial building, housing the 18-inch Brashear telescope, with mounting by Warner and Swasey; the meridian house; and the Director's residence and library.

The longitude was determined in 1912 by exchange of telegraph signals with the U. S. Naval Observatory at Washington on ten nights, and in 1913 by means of wireless signals from Washington on seven nights. The resulting longitude of the dome of the Flower Observatory by the two methods is as follows:

By telegraphic signals $0^h\ 07^m\ 08^s.96$ East from Washington
By wireless signals $08^s.83$ East from Washington

Professor Doolittle adopts the mean of the two determinations as the best value of the longitude.

On the Observed Rotations of Planetary Nebulae.—In *Publications of the Astronomical Society of the Pacific* No. 166 Professor Campbell and Dr. J. H. Moore give some interesting statements concerning the results of recent measures of the spectra of planetary nebulae:—

"We have tested nearly forty planetaries. About twenty give definite evidence of rotational motions or relative motions within the nebulae. For a half dozen others we suspect that the nebular lines are inclined to their normal directions in some cases and distorted from straightness in others, as Doppler effects resulting from motions. In about fifteen cases no indications of rotation or relative motion within the nebulae have been found.

"In general the larger planetaries, and in general the nebulae whose elliptic outlines have the greatest eccentricities, give the strongest evidences of rotation or internal motion.

"The smallest nebulae and the nebulae whose outlines are most nearly circular are the ones in which tests for rotation have failed. . . .

"A number of the ring nebulae give lines of such form as to suggest that the observed phenomena result from a combination of rotational motion and other type or types of motion. . . .

"The observations indicate in general that the outer strata are rotating more slowly than the inner strata, both angularly and linearly. This is, in effect, a lagging behind of the outer strata."

Assuming that the particles in the nebulae are under the ordinary law of gravitation and that the central portion on the average has a mass equal to that of the sun, the writers find that the distances of these nebulae range from 5 to 250 light-years. On the other hand if their distances are as great as 1,000 light-years the minimum values of their masses must lie between 5 and 210 times that of the sun.

SIRIUS---RISING.

Is this some diamond sparkling in the sky
Or brilliant beacon blazing 'mid the depths
Of ether-gulfs stupendous, or perchance
Celestial Castle of some dazzling dream?—
So bright it beams in yonder darkened dome
Where other stars are shining dull and dim.

An hour ago this flashing sun of night
Rose radiant, alone, when northern Earth
Is stripped of all her verdant scenery
And some last leaves still fall, ere winter's snow
Has covered vale and hill with cold, white cloak,
Or Sun ascends his sothern Zodiac.

Once more the Dog-Star reigns in evening's sky
Below the glories of its galaxy.

CHARLES NEVERS HOLMES,
Newton, Mass.,
41 Arlington St.

Errata in "Report on Mars No. 17".—Professor W. H. Pickering calls attention to the following list of errata in his "Report on Mars No. 17", in the December number of POPULAR ASTRONOMY.

On page	642	ninth	line	*for*	like	*read*	as.
" "	643	twenty-first	"	"	1200	"	1300.
" "	"	thirty-sixth	"	"	1916	"	1914
" "	646	thirtieth	"	"	a	"	the.

In	Table II.	No.	18	under	D	*omit*	B, under L *insert* B
"	"	"	25	for	Eumenide	*read*	Eumenides
"	"	"	29	under	L	*insert*	B
"	"	"	40	"	M	*insert*	AB
"	"	"	41	"	L	*insert*	A, under M *omit* AB
"	"	"	42	"	L	*omit*	A
"	"	"	45	"	M	*insert*	C
"	"	"	46	"	M	*for* C *read*	E
"	"	"	47	"	M	*omit*	E
"	"	"	50	"	M	*insert*	B
"	"	"	51	for	B	*read*	F
"	"	"	52	under	M	*omit*	F
"	"	"	54	"	M	*insert*	D
"	"	"	55	"	M	*omit*	D
"	"	"	56	"	M	*insert*	F
"	"	"	57	"	M	*omit*	F
"	"	"	58	"	W	*insert*	B

On	page	648	eighteenth	line	below table	*for*	a *read* the.
"	"	"	twenty-first	"	*after* recorded	*insert*	by each observer.
"	"	"	twenty-second	"	" visibility	"	as deduced.
"	"	649	tenth	"	" only in	"	the case of.
"	"	650	sixth	"	*omit* more.		